

Signaling Empire between the Abbasid-Byzantine Frontier and Constantinople

Investigations on the Ninth-Century Long-Distance Optical Telegraph

LUCAS McMAHON

During the ninth century, a unique medieval Roman long-distance optical telegraph line ran between Loulon, a contested fortress in the Tauros Mountains, and the political center of Constantinople.¹ The telegraph was unusual both for the vast distance covered and for the claim that it could send a range of different messages. How and why it was developed, employed, and shut down tells a story about competition between elites across borders, polities, and languages, the appropriation of the past, and efforts to shore up bonds between center, heartland, and periphery of a state grappling with a long-term crisis. This telegraph was constructed at a moment of intense struggle between Byzantium and the neighboring Abbasid Caliphate, but the focus on its technology has obscured its role in the political, military, and intellectual rivalry between the two major states of western Eurasia in the early Middle Ages.

This study is divided into four sections. First, the telegraph, the textual sources, and optical telegraphy will be introduced. The second section, abbreviated here, asks whether the telegraph as described in the written texts could actually have worked. This is accomplished through what might be (hesitatingly) termed “digital experimental archaeology,” in which GIS (Geographic Information Systems) is employed to determine if the described number of relay sites was

sufficient to cross a vast expanse of Anatolia.² The third section moves from *what* and *how*, to *why*. This section argues that this piece of communication infrastructure ought to be seen primarily as a performative element of empire at a specific moment when Abbasid caliphs personally took the field against the Roman Empire. Finally, the fourth section queries whether the number of beacon stations was influenced by ancient literature.

The Medieval Roman Telegraph

The long-distance telegraph is familiar both to a wider audience as well as students of Byzantine history, either as one of the empire’s technical marvels alongside Greek fire and palace automata or as an example of the revival of intellectual activity in the mid-ninth century. However, aside from a short 1980 monograph by Volker Aschoff, which argued that the system could not work as described, and Philip Pattenden’s 1983 riposte that it could function, it has received little direct attention.³ Some scholarship has viewed the

1 Roman, medieval Roman, and Byzantine will all be used synonymously here. See A. Kaldellis, *Romanland: Ethnicity and Empire in Byzantium* (Cambridge, MA, 2019), 3–120.

2 On the term, see T. G. Whitley, “Geospatial Analysis as Experimental Archaeology,” *Journal of Archaeological Science* 84 (2017): 103–14.

3 V. Aschoff, *Über den byzantinischen Feuertelegraphen und Leon den Mathematiker* (Munich, 1980); P. Pattenden, “The Byzantine Early Warning System,” *Byzantion* 53.1 (1983): 258–99. Leon, the designer of the telegraph system, is here referred to as “the Mathematician,” as per convention, but the funeral epigram for him by his student Constantine of Sicily calls him “the Philosopher,” as do

beacon system as representative of Byzantine optical communications in general.⁴ Others are more skeptical, although outright dismissal is rare.⁵ What is clear is that three interrelated tenth-century texts all report that the emperor Theophilos (r. 829–842) established a long-distance chain of beacons linking the eastern frontier to Constantinople and that the system was abolished shortly thereafter by his son Michael III (r. 842–867). These texts provide a list of names of beacon stations and note some curious details about the telegraph. They allege that the telegraph allowed for different messages to be sent, that the message would reach Constantinople from the frontier within one hour, and that its designer was a certain Leon the Mathematician, who had been headhunted by the Abbasid caliph. The texts all focus on different details but share common themes: the telegraph had its origins in imperial initiative, intellectuals and caliphs played a role, and it was unusual enough that its workings required explanation.

some of the surviving works ascribed to him: L. G. Westerink, “Leo the Philosopher: *Job* and Other Poems,” *JCS* 11.1–2 (1986): 193–222, at 197–98; cf. ὁ μαθηματικὸς Λέων in Theophanes Continuatus, *Chronographia* 4.35 (M. Featherstone and J. Signes Codoñer, ed. and trans., *Chronographiae quae Theophanis Continuati nomine fertur libri I–IV*, CFHB 53 [Berlin, 2015], 280).

4 I. C. Dimitroukas, *Reisen und Verkehr im Byzantinischen Reich vom Anfang des 6. bis zur Mitte des 11. Jh.s* [sic], vol. 1 (Athens, 1997), 306–7; V. L. Adams, “The Visual Communication System of the Early Byzantine Castles along the *Via Axia* in the Republic of Macedonia in the 6th Century AD,” in *Space, Landscapes and Settlements in Byzantium: Studies in the Historical Geography of the Eastern Mediterranean*; Presented to Johannes Koder, ed. A. Külzer and M. S. Popović (Vienna, 2017), 237–49, at 237–38; Ghislaine Noyé, “New Light on the Society of Byzantine Italy,” in *Social Change in Town and Country in Eleventh-Century Byzantium*, ed. J. Howard-Johnston (Oxford, 2020), 157–95, at 184. J. Signes Codoñer, *The Emperor Theophilos and the East, 829–842: Court and Frontier in Byzantium during the Last Phase of Iconoclasm* (Farnham, 2014), 232, does not discuss the beacon system in-depth despite devoting an entire subchapter to Loulon.

5 J. Haldon, “Information and War: Some Comments on Defensive Strategy and Information in the Middle Byzantine Period (ca. A.D. 660–1025),” in *War and Warfare in Late Antiquity*, ed. A. Sarantis and N. Christie (Leiden, 2013), 373–93, at 387; R.-J. Lilie, “Reality and Invention: Reflections on Byzantine Historiography,” *DOP* 68 (2014): 157–210, at 175; B. Anderson, “Public Clocks in Late Antique and Early Medieval Constantinople,” *JÖB* 64 (2014): 23–32, at 30–31; N. G. Wilson, *Scholars of Byzantium*, rev. ed. (London, 1996), 81; A. Kaldellis, *The New Roman Empire: A History of Byzantium* (New York, 2024), 515.

The three texts are the history (*Chronographia*) known by the name of its anonymous author, Theophanes Continuatus, the *Chronicle* of pseudo-Symeon, and the *Book of Ceremonies*. These accounts all come from the circle of Constantine VII (r. 913–959) and thus belong to the program of appropriating and rearranging historical knowledge (*sylloge*) that went on in palatial circles in tenth-century Constantinople.⁶ Theophanes Continuatus and the *Book of Ceremonies* share a brief, similar account that gives the toponyms of the beacon sites, and both criticize Michael III for dismantling the system.⁷ The *Book of Ceremonies* account, however, abbreviates the criticism of Michael and includes a section on what happens after the palace is alerted of an attack and the preparations required of the emperor and his ministers.⁸ Constantine also included a personal address and exhorts the reader, presumably his son the future emperor, Romanos II, to listen to his father.⁹ Slightly later, in the late eleventh or early twelfth century, the historian John Skylitzes largely repeated these accounts but added two notable details: that when people in Asia saw the beacons, they took this as a sign to take refuge in the fortresses, and that when Michael

6 P. Odorico, “La cultura della συλλογή: 1) Il cosiddetto enciclopedia bizantino; 2) Le tavole del sapere di Giovanni Damasceno,” *BZ* 83.1 (1990): 1–21; A. Németh, *The Excerpta Constantiniana and the Byzantine Appropriation of the Past* (Cambridge, 2018), 23–87, 145–64; C. Holmes, “Byzantine Political Culture and Compilation Literature in the Tenth and Eleventh Centuries: Some Preliminary Inquiries,” *DOP* 64 (2010): 55–80; I. Ševčenko, “Re-Reading Constantine Porphyrogenitus,” in *Byzantine Diplomacy: Papers from the Twenty-Fourth Spring Symposium of Byzantine Studies, Cambridge, March 1990*, ed. J. Shepard and S. Franklin (Aldershot, 1992), 167–95. See also the more nuanced appraisal of P. Magdalino, “Knowledge in Authority and Authorised History: The Imperial Intellectual Programme of Leo VI and Constantine VII,” in *Authority in Byzantium*, ed. P. Armstrong (Leiden, 2013), 187–209. This program constructed a history for the Macedonian dynasty. For how this shaped the tenth-century understanding of the mid-ninth-century Abbasid-Byzantine frontier, see C. Dixon, *The Paulicians: Heresy, Persecution and Warfare on the Byzantine Frontier, c. 750–880* (Leiden, 2022), esp. 109–39, 298–320.

7 Theophanes Continuatus, *Chronographia* 4.35 (Featherstone and Signes Codoñer, *Chronographiae*, 280–82); Constantine VII, *Text C* 132.618–34.630 (J. Haldon, ed. and trans., *Constantine Porphyrogenitus: Three Treatises on Imperial Military Expeditions*, CFHB 28 [Vienna, 1990], 132).

8 Constantine VII, *Text C* 132.618–34.646 (Haldon, *Three Treatises*, 132–34).

9 Constantine VII, *Text C* 132.607–17 (Haldon, *Three Treatises*, 132–33).

ordered the system shut down, he only ordered the parts closest to Constantinople disabled.¹⁰

The longest account of the beacons is in the text commonly identified by its author, pseudo-Symeon.¹¹ Pseudo-Symeon, likely writing in the 970s, postdates the work of the Constantinian excerptors, and while the text remains unedited and thus in need of further examination, the author evidently had good access to sources.¹² These sources included the *Book of Ceremonies* and Theophanes Continuatus (the latter probably through the work of Symeon the Logothete¹³), and while this explains the inclusion of the names of the beacon stations and Michael's decision to shut down the system, the author adds some crucial technical details not included elsewhere. Specifically, pseudo-Symeon notes that the innovation introduced by the designer of the system, Leon the Mathematician, was the inclusion of synchronized clocks at either end of the chain. The beacons were thus capable of transmitting different messages based upon which hour of the day they had been lit. The first hour was for an Arab raid (ἐκδρομή), the second for war (πόλεμος), the third for fire (ἐμπρησμός), and the fourth "if another thing" happened (εἰ ἄλλο τι).¹⁴ Constantine VII specifies that the message was delivered in one hour.¹⁵ In

theory, this system could deliver up to twelve different messages.¹⁶

Although not specifically about the optical telegraph, one near-contemporary text discusses optical communications with a similar interest in improving on the amount of information that such systems could send. The military manual attributed to Syrianos Magister discusses how to communicate more complex messages such as lighting a fire twice if the movement sighted is uncertain, three times upon seeing the enemy, or four if there is a particularly large force.¹⁷ The simplicity of visual communications in the ancient and medieval Mediterranean was evidently something that certain ninth- and tenth-century Byzantines thought could be improved upon. Such communications had traditionally been accomplished through signals, especially the use of fire and smoke, occasionally enhanced by items with reflective properties.¹⁸ Military texts and historiography point to

10 John Skylitzes, *Synopsis historiarum* Michael III 19 (I. Thurn, ed., *Ioannes Scylitzae Synopsis historiarum*, CFHB 5 [Berlin, 1973], 107–8). For the dating, see C. Holmes, *Basil II and the Governance of Empire (976–1025)* (Oxford, 2005), 80–89.

11 Pseudo-Symeon, *Chronographia* Michael and Theodora 46 (I. Bekker, ed., *Theophanes Continuatus, Ioannes Cameniata, Symeon Magister, Georgius Monachus*, CSHB 45 [Bonn, 1838], 681–82). Text reproduced with translation in Pattenden, "Early Warning," 258–59.

12 L. Neville, *Guide to Byzantine Historical Writing* (Cambridge, 2018), 121; W. Treadgold, *The Middle Byzantine Historians* (Basingstoke, 2013), 221–22. The Constantinian works existed in only a few copies and were kept in the palace, limiting their circulation: Németh, *Byzantine Appropriation*, 35–36.

13 S. Wahlgren, "Symeon the Logothete and Theophanes Continuatus," *JÖB* 69 (2019): 323–33, at 331–33. Constantine VII's historical program was in direct competition with Symeon the Logothete: Magdalino, "Knowledge in Authority and Authorised History," 203–6.

14 Pseudo-Symeon, *Chronographia* Michael and Theodora 46 (Bekker, *Symeon Magister*, 681–82). Translation in Pattenden, "Early Warning," 259.

15 Constantine VII, *Text C* 132.614–16 (Haldon, *Three Treatises*, 132). In contrast, Stanford's ORBIS software (<https://orbis.stanford.edu/>) suggests a journey of about four-and-a-half days from Tarsos to Constantinople on the fast post (*cursus velox*). Loulon is closer to Constantinople than Tarsos, but ORBIS is node based and thus has a fixed number of locales from which it can simulate travel in Cilicia or

Cappadocia. The Byzantine state post (*dromos*) attained similar speeds, although routes moved slightly to the west after the seventh century: J. Fossella, *The Dromos and Byzantine Communications, Diplomacy, and Bureaucracy, 518–1204* (Leiden, 2023), 40–46, 118; T. Kaya, "Understanding the Use of Byzantine Routes in Central Anatolia (ca. 7th–9th Centuries)," *Studia Ceranea* 9 (2019): 259–78, at 261–70.

16 For twelve potential messages in total, see pseudo-Symeon, *Chronographia* Michael and Theodora 46 (Bekker, *Symeon Magister*, 681–82). Translation in Pattenden, "Early Warning," 259. P. Lemerle, *Byzantine Humanism: The First Phase; Notes and Remarks on Education and Culture in Byzantium from Its Origins to the 10th Century*, trans. H. Lindsay and A. Moffatt (Canberra, 1986), 179–80, defends this number.

17 Syrianos Magister, *Peri strategias* 8 (G. T. Dennis, ed. and trans., "The Anonymous Byzantine Treatise on Strategy," in *Three Byzantine Military Treatises*, CFHB 25 [Washington, DC, 1985], 10–136, at 26). For the date, see C. Zuckerman, "The Military Compendium of Syrianus Magister," *JÖB* 40 (1990): 209–24; P. Rance, "The Date of the Military Compendium of Syrianus Magister (Formerly the Sixth-Century Anonymus Byzantinus)," *BZ* 100.2 (2007): 701–37. In addition, the *Apparatus Bellicus*, an undated military text in Greek, used left, center, and right signal fires to send messages encoded to particular letters of the Greek alphabet: C. Zuckerman, "Chapitres peu connus de l'*Apparatus Bellicus*," *TM* 12 (1994): 359–89, at 361–62. While this text has been linked to the eighth or ninth century based upon its references to a fixed line of signal posts, the vast distances described raise questions about its functionality, and the argument behind this dating is not secure. See also R. J. Forbes, *Studies in Ancient Technology*, vol. 6 (Leiden, 1958), 176–77.

18 A. T. Hodge, "Reflections on the Shield at Marathon," *BSA* 96 (2001): 237–59; A. C. Leighton, "Secret Communication among the Greeks and Romans," *Technology and Culture* 10.2 (1969): 139–54, at 146, n. 37. Maurikios, *Strategikon* VII.B.15 (G. T. Dennis, ed., and E. Gamillscheg, trans., *Das Strategikon des Maurikios*, CFHB 17

such things being used in Byzantium, as does the siting of fortifications within sight lines of each other.¹⁹ Earlier efforts to innovate beyond the binary on-off of a fire or smoke signal can be found in the second-century BCE Greek *Histories* of Polybios, who discussed two systems for sending more complex messages over long distances. The first of these was for short-range communications and involved the movement of a pair of torches that corresponded to a cipher, which then spelled out words.²⁰ The second is preserved only in Polybios but is attributed to the fourth-century BCE military writer Aineias Taktikos and is more akin to the Byzantine system.²¹ It was explicitly for relaying information of military interest and involved synchronized water clocks, with a rod in the water with gradations marked on it, each corresponding to a particular message. When the water level reached the intended message, the signaler would raise a torch, and the recipient would look to their own water clock to understand the message. Polybios was not impressed with this system and introduces it by way of showing how the torch system he designed was superior.²² It was only for short ranges, and Polybios's description makes it seem like it operated only between a watch post and a more central location because torch signals were employed bidirectionally to synchronize the clocks.²³ Whether this was known in the ninth century is unclear, but given Byzantium's contribution to preserving the canon of ancient Greek literature that survives to the present,

it is very possible.²⁴ Pseudo-Symeon also emphasized that Leon's innovation was linked to the synchronized clocks.²⁵ This system thus attempted to improve upon a fundamental problem with optical signaling techniques passed down from antiquity: the inability to transmit more than a tiny amount of information. Despite some lofty claims, the Romans did not notably improve upon Greek signaling.²⁶ More complex instructions could be disseminated at shorter ranges with, for example, flags.²⁷ However, here nine named stations have to transmit a message across some 600 km, distances extreme enough that the curvature of the Earth becomes a limiting factor in visibility. This is much too far for the human eye to distinguish flags or multiple fires. Beacons are thus ones or zeros, on or off. No evidence points to the use of reflective materials or optical enhancements for the functioning of the telegraph, although such things were known and did exist.²⁸ The trick of the Byzantine system was to say something more within these binary restrictions. The chosen solution to this was the synchronized clock system, which will be discussed later. The more immediate problem, though, was the distance between stations.

An Experiment

The fundamental issue is that the distance per relay of the Byzantine telegraph greatly exceeds most known historical beacon systems prior to the late nineteenth

[Vienna, 1981], 258), emphasizes covering up all potentially shiny metal prior to battle.

19 N. D. Kontogiannis and M. Heslop, "The Defences of Middle Byzantium in Greece (Seventh–Twelfth Centuries)," in *Medieval Greece: Encounters between Latins, Greeks and Others in the Dodecanese and the Mani*, by M. Heslop (Abingdon, 2021), 175–95.

20 Polybios, *Historiae* 10.45–46 (L. Dindorf, ed., and rev. by T. Büttner-Wobst, *Polybii Historiae*, vol. 3 [Stuttgart, 1985], 118–21). Polybios was familiar in Byzantium, and his works were employed in the compilation projects of Constantine VII: L. I. Hau, "The Fragments of Polybios Compared with Those of the 'Tragic' Historians Duris and Phylarchus," *Histos* 15 (2021): 238–82.

21 Polybios, *Historiae* 10.44 (Dindorf and Büttner-Wobst, *Historiae*, 3:116–18); Forbes, *Studies in Ancient Technology*, 6:173–74.

22 Polybios, *Historiae* 10.44–45 (Dindorf and Büttner-Wobst, *Historiae*, 3:116, 119). Generally, see T. E. Rihll, "Technology in Aineias Tacticus: Simple and Complex," in *Brill's Companion to Aineias Tacticus*, ed. M. Pretzler and N. Barley (Leiden, 2018), 265–89, at 281–87.

23 Polybios, *Historiae* 10.44.10 (Dindorf and Büttner-Wobst, *Historiae*, 3:118).

24 A. Kaldellis, *Byzantium Unbound* (Leeds, 2019), 57–65.

25 Pseudo-Symeon, *Chronographia* Michael and Theodora 46 (Bekker, *Symeon Magister*, 681–82). Translation in Pattenden, "Early Warning," 258–59.

26 See Forbes, *Studies in Ancient Technology*, 6:176–77, for the exception of the efforts of Sextus Julius Africanus to improve upon Polybios's systems. D. J. Woolliscroft, *Roman Military Signalling* (Stroud, 2001), argues for sophisticated intervisibility of Roman defensive works in Britain and along the Rhine, but G. H. Donaldson, "Signalling Communications and the Roman Imperial Army," *Britannia* 19 (1988): 349–56, is convincing in his position that Roman signals were typically simple and local.

27 J. Pryor and E. Jeffreys, *The Age of the ΔΡΟΜΩΝ: The Byzantine Navy ca. 500–1204* (Leiden, 2006), 396–99.

28 J. Bruning, "A Call to Arms: An Account of Ayyubid or Early Mamluk Alexandria," *Al-'Uṣūr al-Wuṣṭā* 28 (2020): 74–115, at 91–92. While their function is uncertain, the rock crystal Visby lenses were likely manufactured in the eastern Mediterranean before the eleventh century and have refractive properties: O. Schmidt, K.-H. Wilms, and B. Lingelbach, "The Visby Lenses," *Optometry and Vision Science* 76.9 (1999): 624–30.

century, when an experiment using mirrors in the Indian Ocean managed to flash light over distances of 200 km.²⁹ The hypothetical Anglo-Saxon signaling system between Chichester and London (approximately 90 km) has six toponyms that include an Old English word for “lookout place,” but not all of these sites are intervisible, which suggests that some relays were needed.³⁰ Distances between the beacons of the sixth-century Byzantine signaling system along the Via Axia in Macedonia rarely exceeded 25 km.³¹ In tenth-century Frankia, when the party of the future king Louis IV at Boulogne wanted to signal their arrival to the Anglo-Saxon king Æthelstan on the other side of the English Channel, they needed to light multiple structures on fire despite the distance being only about 50 km.³² The beacon towers constructed in late fourteenth-century Ming China as part of the Great Wall system were some 10–15 km apart.³³ The Byzantine/Venetian optical signaling network on Euboea ranged from 8 to 14 km between nodes.³⁴ The author of a classic visibility study was impressed that a burning yucca tree in the American southwest could be seen at night from 42 km away, although ethnographic evidence suggests that signals could be sent at 70 km.³⁵ In contrast, the range at which the human eye can detect person-sized objects or movement is more limited. Under ideal conditions, with a subject standing out distinctly from the landscape while moving and the observer actively looking for them, a person can be seen at 2.5 km. Clothing becomes visible at 800 m, but physical features only at 30–60 m. For the nine stations to cross the approximately 600 km from

Loulon to Constantinople, a station would be needed every 66 km, at a minimum. This is clearly much more than other historical systems and pushes the boundaries of what the human eye can see. Are the number of relays described in the texts actually sufficient to bridge the distance, and how might one determine this? Tools from the digital humanities present a means of answering this query.

The viewshed is a GIS computational technique in which the algorithm determines whether any given cell in a landscape is visible from a particular defined point. Studies of historical visibility tend to examine a much larger number of places in compact regions, but this will not work here.³⁶ A hypothetical beacon line must be established before any work can be done on who—other than the next beacon—might be able to see any particular lit beacon. The lack of securely attributed beacon sites makes intervisibility important: for the sake of the experiment, high points are used to find other high points. Previous scholarship on beacon sites in the Anglo-Saxon realms has demonstrated that elevation and visibility are more important in identifying such locations than archaeological remains, which tend to be meager.³⁷

GIS analysis is not a science but should still adhere to the principle of replication. Replication in science entails that the results of any given experiment should include enough information so that others can reproduce the experiment and, in theory, achieve the same results. This section details the methods employed and places examined and is by necessity technical. Readers who wish only to know whether the number of beacons described in the texts can *technically* bridge the distance between Loulon and Constantinople can rest easy that the argument is affirmative, and they may now skip to the next section.

29 Aschoff, *Feuertelegraphen*, 17.

30 Gower, “A Suggested Anglo-Saxon Signalling System between Chichester and London,” *London Archaeologist* 10.3 (2002): 59–63.

31 Adams, “Visual Communication System,” 241–49.

32 Richer of Saint-Rémi, *Histories* 2.4 (Richer of Saint-Rémi, *Histories*, vol. 1, ed. and trans. J. Lake [Washington, DC, 2011], 167).

33 T. Wilmott, “Towers and Spies on Chinese and Roman Frontiers,” in *The Army and Frontiers of Rome*, ed. W. S. Hanson (Portsmouth, RI, 2009), 129–33, at 129–30.

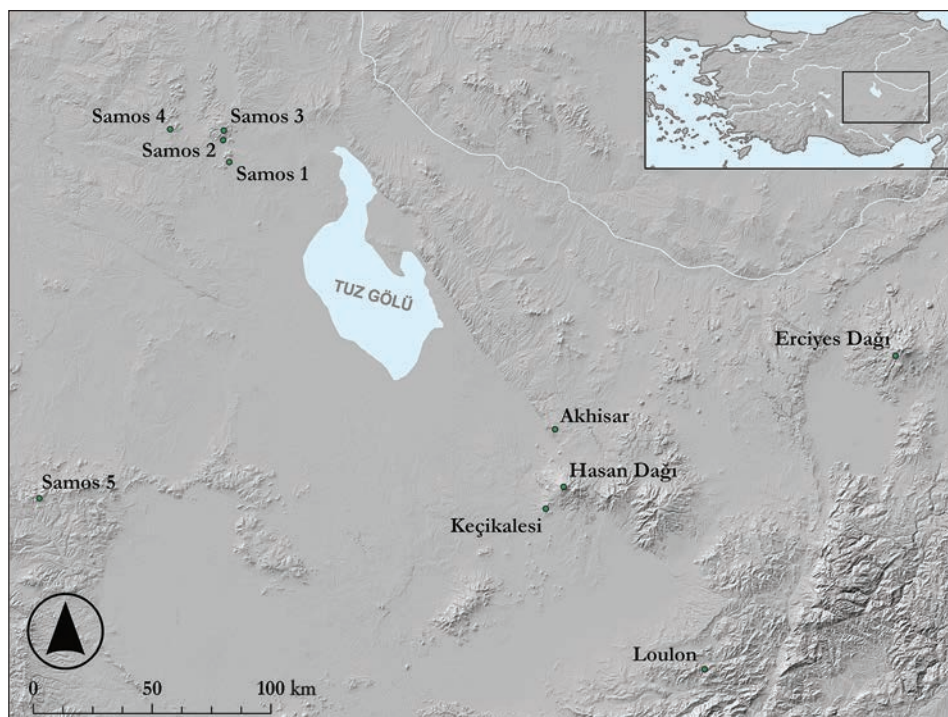
34 A. Blackler, “Communication and the Role of the Medieval Tower in Greece: A Re-Appraisal,” *BSA* 117 (2022): 393–414, at 409.

35 S. Swanson, “Documenting Prehistoric Communication Networks: A Case Study in the Paquimé Polity,” *American Antiquity* 68.4 (2003): 753–67, at 755; P. Fábrega-Álvarez and C. Parceró-Oubiña, “Now You See Me: An Assessment of the Visual Recognition and Control of Individuals in Archaeological Landscapes,” *Journal of Archaeological Science* 104 (2019): 56–74, at 61–64.

36 R. M. Van Dyke et al., “Great Houses, Shrines, and High Places: Intervisibility in the Chacoan World,” *American Antiquity* 81.2 (2016): 205–30, at 205–26; T. Earley-Spadoni, “Landscapes of Warfare: Intervisibility Analysis of Early Iron and Urartian Fire Beacon Stations (Armenia),” *Journal of Archaeological Science: Reports* 3 (2015): 22–30; E. J. Marsh and K. Schreiber, “Eyes of the Empire: A Viewshed-Based Exploration of Wari Site-Placement Decisions in the Sondondo Valley, Peru,” *Journal of Archaeological Science: Reports* 4 (2015): 54–64, at 58, who limit their viewsheds to 10 km.

37 J. Baker and S. Brookes, “Signalling Intent: Beacons, Lookouts and Military Communications,” in *The Material Culture of the Built Environment in the Anglo-Saxon World*, ed. M. C. Hyer and G. R. Owen-Crocker (Liverpool, 2015), 216–34, at 222–28.

Fig. 1.
Sites mentioned in the
text, southeast sector.
Map by the author.



The digital elevation model (DEM) was constructed from NASA's ASTER Global Digital Elevation Model V003 and the projection used was WGS1984.³⁸ The entirety of Anatolian Turkey west of 37° longitude was included. The Geodesic Viewshed in ArcGIS Pro 3.3.0 was used (Figs. 1–3).³⁹ The list of locales is available in the Appendix. The ease of taking viewsheds permits a quick, albeit imperfect, analysis of some of the proposed locations for these sites and their suitability in terms of visibility. Unless otherwise indicated, all tests assume

10 m of elevation above the ground.⁴⁰ Towers for local defensive purposes were higher, but the sheer distances involved between some beacons suggest that we might rather be looking at platforms instead of towers given the size of the pyres they would have had to accommodate.⁴¹ The full details of the experiment will not

38 NASA, "Earthdata Search," [https://search.earthdata.nasa.gov/search/granules?p=C1711961296-LPCLOUD&pg\[o\]\[gsk\]=-start_date&ff=Map%20Imagery&tl=1621940847.488!3!!](https://search.earthdata.nasa.gov/search/granules?p=C1711961296-LPCLOUD&pg[o][gsk]=-start_date&ff=Map%20Imagery&tl=1621940847.488!3!!), accessed 18 October 2024. At 30 m to the pixel, this DEM is the best freely available elevation raster dataset of the region, and data of equivalent quality has been employed successfully in similar studies: Earley-Spadoni, "Uartian Fire Beacon Stations," 25; K. Supernant, "Intervisibility and Intravisibility of Rock Feature Sites: A Method for Testing Viewshed within and outside the Socio-Spatial System of the Lower Fraser River Canyon, British Columbia," *Journal of Archaeological Science* 50 (2014): 497–511, at 502.

39 ArcGIS's calculations were checked manually using the following formula for distance to horizon at altitude: $\sqrt{(A_O - A_H) \cdot (2 \cdot [r + A_H] + [A_O - A_H])}$, where A_O is the altitude of the observer, and A_H is the altitude at the horizon.

40 Not all sites would necessarily leave an archaeological footprint: Blackler, "Role of the Medieval Tower," 407. The exception to this offset above ground is Loulon, which has been set to 25 m. Loulon was reputed as having a good view: A. Vasiliev, *Byzance et les Arabes*, vol. 2 (Brussels, 1935), 136.

41 J. L. Rife, "Leo's Peloponnesian Fire-Tower and the Byzantine Watch-Tower on Acrocorinth," in *Archaeology and History in Roman, Medieval and Post-Medieval Greece: Studies on Method and Meaning in Honor of Timothy E. Gregory*, ed. W. R. Caraher, L. J. Hall, and R. S. Moore (Aldershot, 2008), 281–306, at 297. Rife sets the Acrocorinth tower at 15–25 m, whereas J. Turchetto and G. Salemi, "Hide and Seek: Roads, Lookouts and Directional Visibility Cones in Central Anatolia," *Open Archaeology* 3 (2017): 69–82, at 73, use 7 m as the height of an average fortification wall in Cappadocia. These are dwarfed by the (entirely hypothetical) 45 m Roman signal towers near York: T. W. Bell, "A Roman Signal Station at Whitby," *AJ* 155.1 (1998–1999): 303–22, at 314–16. Surviving Byzantine towers from the tenth and eleventh centuries in Italy are 20–25 m in height, for example at Castelluccio Valmaggiore and Biccari in Puglia. Visibility analysis on the Dacian *limes* uses variable heights of 8–12 m for the towers: V.-A. Lăzărescu, Ș. Bilașco, and I. Vescan, "Big Brother Is Watching You!



Fig. 2.
Sites mentioned in the
text, central sector.
Map by the author.



Fig. 3.
Sites mentioned in the
text, northwest sector.
Map by the author.

be given at length here, as dozens of sites were tested. Locations suggested by previous scholarship were tested prior to locally prominent features. Finding the precise location of a beacon station is likely impossible, as even main, named sites were supported by a range of outposts and watchtowers, which fieldwork around Euchaïta in north-central Anatolia has revealed.⁴² Intervisibility between sites was a general operating principle, and only when such points became exhausted were others sought out. Multiple viewsheds were taken from any given point to ensure reliability. The goal was not to identify precise sites but merely to determine whether the chain as described was possible at all. The following discussion will proceed through the named stations and, with viewsheds, attempt to determine whether their number was sufficient to span Anatolia.

The efforts of William Ramsay in the nineteenth century and the *Tabula Imperii Byzantini* (TIB) team in the twentieth made headway toward establishing approximate locations of the beacon sites. Nine locations were mentioned in the medieval sources: Loulon, Argaios, Samos/Isamos, Aigilos, the Hill of St. Mamas, Kyrizos, Mokilos, the Hill of St. Auxentios, and Pharos.⁴³ Of these, only the first and last are quite certain. Loulon has been identified as a sharp peak with medieval remains between the villages of Gedelli and Çanakçı in the Tauros range.⁴⁴ Pharos was the lighthouse tower on the sea walls in Constantinople.⁴⁵

Approaching Roman Surveillance and Signalling at *Porolissum*,” in *Landscape Archaeology on the Northern Frontier of the Roman Empire at Porolissum*, ed. C. H. Opreanu and V.-A. Lăzărescu (Cluj-Napoca, 2016), 275–353, at 277.

42 J. Newhard, N. S. Levine, and O. Adams, “Appendix 3: Assigning Function to Survey Data Using Heuristic Geospatial Modelling,” in *Archaeology and Urban Settlement in Late Roman and Byzantine Anatolia: Euchaïta-Avkat-Beyözü and Its Environment*, ed. J. Haldon, H. Elton, and J. Newhard (Cambridge, 2018), 274–82.

43 Constantine VII, *Text C* 132.618–34.630 (Haldon, *Three Treatises*, 132–34); Theophanes Continuatus, *Chronographia* 4.35 (Featherstone and Signes Codoñer, *Chronographiae*, 280).

44 F. Hild and M. Restle, *Kappadokien: Kappadokia, Charsianon, Sebasteia und Lykandos* (Vienna, 1981), 223–24.

45 R. Janin, *Constantinople byzantine: Développement urbain et répertoire topographique* (Paris, 1950), 409; J. Bardill, “The Great Palace of the Byzantine Emperors and the Walker Trust Excavations,” *JRA* 12 (1999): 216–30, at 216, 226. Theophanes Continuatus explicitly states the receiving station was on the terrace (ἡλιακός): Theophanes Continuatus, *Chronographia* 4.35 (Featherstone and Signes Codoñer, *Chronographiae*, 280).

Ramsay thought Argaios was the extinct volcano Hasan Dağı, noting that the summit had a spectacular view and believing that Strabo’s name for the mountain (Argos) had been modified in Byzantine times to Argaios.⁴⁶ Others are less certain. Aschoff and Pattenden prefer Erciyes Dağı, while Aschoff notes that the summit is high enough that it remains snowbound even in the summer, and thus places the beacon somewhere on its slopes.⁴⁷ On the other hand, Friedrich Hild and Marcell Restle identify Argaios as Keçikalesi, a Byzantine fortress to the southwest of Hasan Dağı.⁴⁸ Viewsheds taken from the peaks and slopes of both volcanoes reveal extensive views, but also difficulties. Erciyes Dağı struggles to see Loulon as well as across Tuz Gölü, a problem since this is Ramsay’s proposed location of Samos. Any fire on Erciyes Dağı would have to be massive: the small chain of hills to the north of Tuz Gölü are around 240 km distant. Hasan Dağı is more promising as the site of Argaios, as multiple locations from the mountain are able to see both Loulon and across Tuz Gölü.

Keçikalesi, the site proposed by Restle and Hild, is a fortification situated on a range of hills at the base of Hasan Dağı. This site has much to recommend it: medieval ruins and a viewshed that can see both Loulon (without having to incorporate any offsets to account for built structures) and all the way across Tuz Gölü. The site itself is not especially prominent, but its visibility ranges are not significantly worse than the peak of Hasan Dağı, which towers 1500 m above it. Furthermore, the two volcanoes dominate their environments but are largely barren, and any fuel would need to be transported uphill some 1500–2000 m. However, Syrianos, the author of a ninth-century Byzantine military manual, suggests that the best observation posts are on level, open ground, and Keçikalesi

46 W. M. Ramsay, *The Historical Geography of Asia Minor* (London, 1890), 352–53.

47 Pattenden, “Early Warning,” 267–68; Aschoff, *Feuertelegraphen*, 11–12. Hild and Restle, *Kappadokien*, 149, do not mention the telegraph for the entries on Argaios, but see K. Belke and M. Restle, *Galatien und Lykaonien* (Vienna, 1984), 180, where Argaios is identified as Hasan Dağı.

48 Hild and Restle, *Kappadokien*, 136–38. Turchetto and Salemi, “Hide and Seek,” 80, do not discuss it further but seem uncertain. R. G. Ousterhout, *Visualizing Community: Art, Material Culture, and Settlement in Byzantine Cappadocia* (Washington, DC, 2017), 341–43, is sufficiently confident in Keçikalesi being Argaios to identify a signaling platform near the northern postern.

qualifies.⁴⁹ With other nearby fortifications, Keçikalesi controls roads between the south and east of the Tauros and the Anatolian plateau.⁵⁰ Hild and Restle's suggestion seems increasingly probable: Keçikalesi has limited views to the west, and only two beacons are named between Argaïos and the Hill of St. Mamas. If the Hill of St. Mamas is Bithynian Olympos (Uludağ), as seems likely, then the area of the Porsuk (ancient Tembris) valley is from where these beacons need to be visible.⁵¹

The location of Samos, the next named beacon site, is uncertain. Ramsay supposed it was somewhere northwest of Tuz Gölü, Pattenden agreed, and Belke and Restle noted that the location could not be identified.⁵² The land to the north and west of Tuz Gölü is composed of low rolling hills, a problem for long-distance visibility. While a number of these hills have viewsheds that extend to Keçikalesi, the distances are upward of 120 km. More problematically, however, views to the west and north are limited. Viewsheds were taken from a number of hills in the area. About 40 km west of the shore of the lake and immediately west of the village of Karacadağ, a small chain of rocky, barren hills dominates the surrounding landscape to the extent that they were visible (albeit at extreme ranges) from the two volcanoes and Keçikalesi. This is Samos 1, and despite it not being on a mountain peak, a viewshed analysis reveals this to have decent views to the east and south of the surrounding area. The view stretches south nearly 150 km and includes Hasan Dağı and Keçikalesi. While a beacon sited here might be able to see Keçikalesi, the location has limited views to the west. While intervisibility between beacon sites is not strictly required, it is generally assumed and rather important in this case since intervisibility is being used to identify potential beacon sites due to the lack of other evidence. Samos 2, a slightly higher hill 8 km north of Samos 1, offers more restricted views to the south due to being blocked by the hill on which the first Samos site was

placed. While this second potential Samos site can also see Keçikalesi, it has limited visibility toward the west. A second attempt with a 25 m offset above the ground did not improve the results. Samos 3, just slightly to the north of Samos 2 but at a greater elevation, has similar views to the south but is only a marginal improvement to the west. This site sits at the highest elevation of any of the hills in the Keçikalesi viewshed and is commended by presently being home to a radio mast. The views are unimpressive toward the west, and once again, a second test of the same site with an additional 25 m of elevation does not improve the viewshed. While it is remarkable that these three sites can all see Keçikalesi, which is more than 150 km to the south, none have much visibility toward the west. A fourth attempt (Samos 4) was identified at the extreme edge of the Keçikalesi viewshed and might possess some sort of remains. The viewshed here is poor, with some capacity to see west, but Keçikalesi is not visible. The rolling hills of the central plateau create problems with long-distance visibility. The test of a fifth potential Samos site on a peak approximately 40 km northeast of Konya has some commendable features. It is intervisible with Keçikalesi and can see as far north as Mt. Dindymon (Arayit Dağı), which is 140 km distant.⁵³

One possibility is that Ramsay's belief that the beacon line went over Tuz Gölü is in error. A second possibility is that Samos and the next site, Aigilos, are not intervisible. Aigilos was placed by Ramsay somewhere around Kaymaz, and by Belke and Restle around Sivrihisar.⁵⁴ Perhaps a site up the Porsuk Valley in the vicinity of Dorylaion (Eskişehir) can see these hills near Tuz Gölü but cannot be seen from there? The first was fairly easy to test: Keçikalesi can see only a few points to the west, and Aigilos needs to be able to be seen from Uludağ so the general area to be examined is limited. Three functional Aigilos sites were eventually identified: Mt. Dindymon, Hill 2606m, and Aigilos 3.

Mt. Dindymon itself was tested first and proves promising: it can see all five Samos sites (Fig. 4). Sivrihisar is 25 km northeast of the peak of Dindymon. As Ramsay points out, long-distance optical communications are difficult in such broken country, and none of the first four sites potentially identified as Samos can

49 Syrianos Magister, *Peri strategias* 6 (Dennis, "Anonymous Byzantine Treatise," 24).

50 Turchetto and Salemi, "Hide and Seek," 75–81.

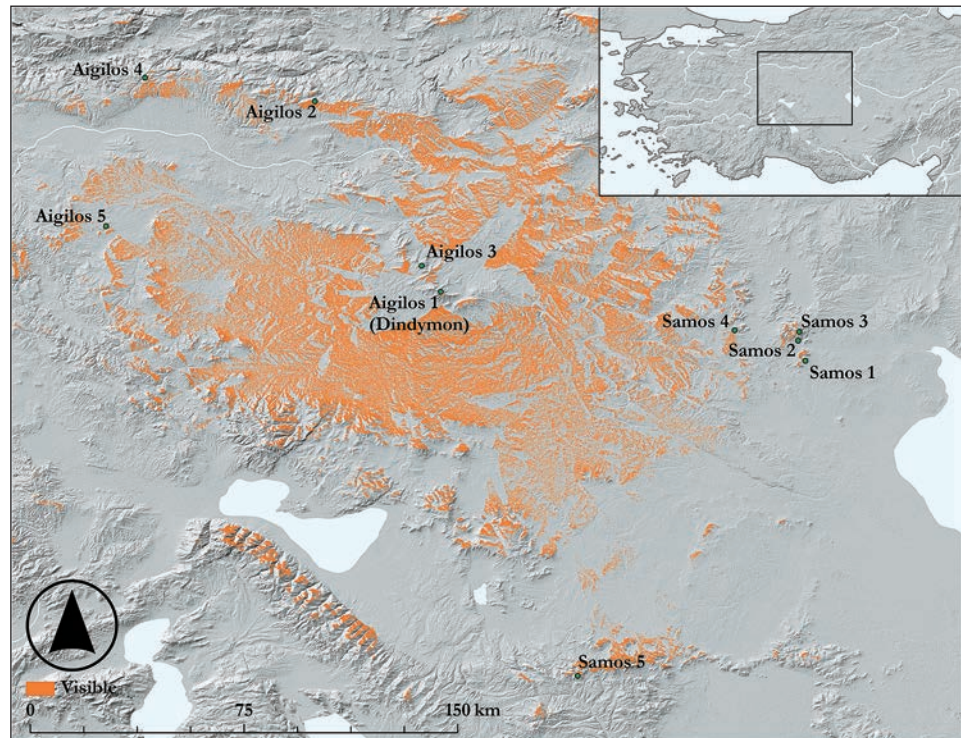
51 K. Belke, *Bithynien und Hellespont*, 2 vols. (Vienna, 2020), 2:752.

52 Ramsay, *Historical Geography*, 352; Pattenden, "Early Warning," 268; Belke and Restle, *Galatien und Lykaonien*, 180. Ousterhout did not go so far as to identify Akhisar, a known site 35 km north of Keçikalesi, as Samos: Ousterhout, *Visualizing Community*, 341–43. A viewshed taken from 20 m above ruins on the site suggests that it could not see Keçikalesi, although otherwise it has good views of the surrounding Cappadocian landscape.

53 For the identification of this peak with Dindymon, see Belke and Restle, *Galatien und Lykaonien*, 158–59.

54 Ramsay, *Historical Geography*, 353. Aigilos is unknown to Belke and Restle, *Galatien und Lykaonien*, 117–18, 158–59.

Fig. 4.
Viewshed from
Aigilos 1
(Mt. Dindymon).
Map by the author.



see the chain of hills between Kaymaz and Sivrihisar. Notably, the viewshed from the peak of Mt. Dindymon can see the eastern edge of Uludağ, 230 km to the northwest. Uludağ can see Mt. Dindymon, but the result is not entirely satisfying as the locations are at the extreme edge of each other's viewsheds. Moreover, Mt. Dindymon was a known, named place, so calling it something else in the medieval sources is an odd solution.

Could any known Byzantine sites in the vicinity of Dorylaion or the Porsuk Valley have been Aigilos? Karacaşehir, a substantial medieval fortress immediately south of Eskişehir, can see the eastern side of Uludağ and occupies a strong position on a hill but has limited views east, even with a ground-level offset of 50 m.⁵⁵ The Hittite mound at Byzantine Midaion (Karahüyük) offers only local views.⁵⁶ A few kilometers northeast of Karahüyük is Osmaniye, a location of unknown Byzantine name but where sculptural fragments have been found.⁵⁷ Lacking even a tell, however, its viewshed is limited to a few surrounding peaks. Even with

a 50 m offset above the ground, Byzantine Troknada (Kaymaz) cannot see very far. The problem with all of these locations is that they are in the river valley and lack the necessary elevation for long-distance views. Thus, locales at higher elevation were investigated. A series of local masking polygons and a tool for finding highest and lowest points were employed in the Konya-Eskişehir-Ankara area. One mountaintop about 90 km northeast of Dorylaion (here referred to as Hill 1812m based on its elevation) was identified. While it has good views and can see the eastern side of Uludağ, it cannot see as far as any of the potential Samos sites. A second prominent peak at 2600 m (Hill 2606m) in the Sultandağ range could fulfill the conditions for the Aigilos beacon site. It can see all five of the potential Samos sites as well as the eastern edge of Uludağ, 230 km to the north. The reverse is also true, and the location selected on Uludağ is inter-visible. However, this is once again an extreme distance.

Might any other sites work? Three more potential sites for the Aigilos beacon were tested, named Aigilos 2–5. The first of these is just south of Hill 1812m. The hope was to find a midpoint between Uludağ and the sites northwest of Tuz Gölü to follow up on Ramsay's hypothesis. While Aigilos 2 has good local views, a series of hills block the four potential Samos sites in that

55 K. Belke and N. Mersich, *Phrygien und Pisidien* (Vienna, 1990), 290–91.

56 Belke and Mersich, *Phrygien und Pisidien*, 341–42.

57 Belke and Mersich, *Phrygien und Pisidien*, 352.

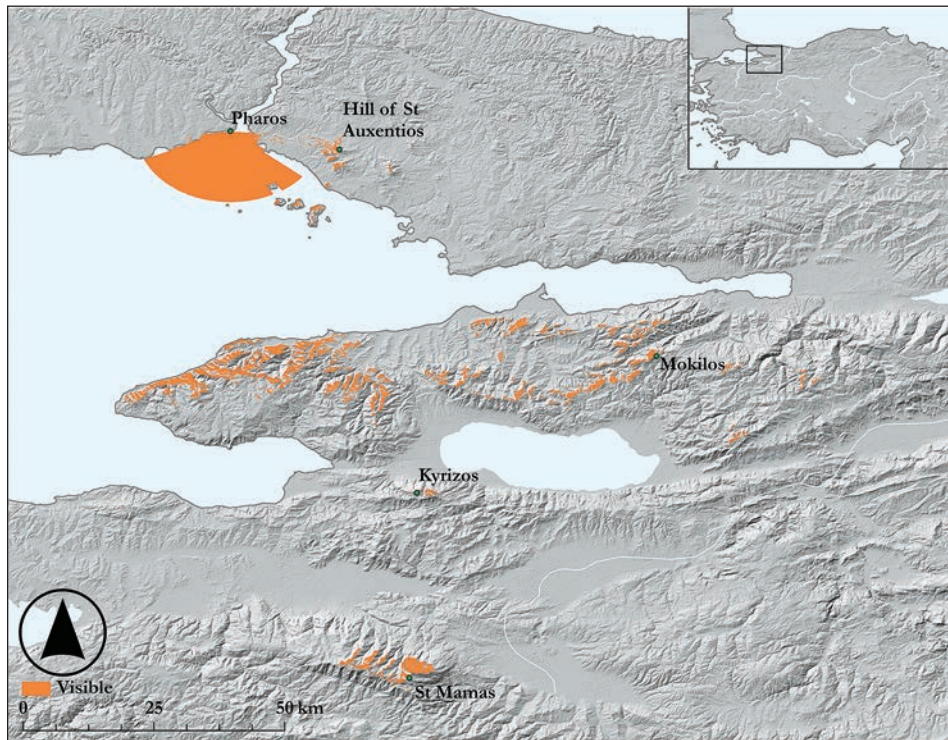


Fig. 5.
Viewshed from
Pharos. Map by
the author.

direction. Samos 5 is more than 200 km distant and not visible, nor is St. Mamas. Aigilos 3 attempts to examine another peak near Mt. Dindymon to follow up on Ramsay's belief that Aigilos was southeast of Dorylaion. This location works—it can see Samos 1–4 to the east and a few distant peaks near Samos 5, which means that the southern route cannot be ruled out. The location can also be seen from Uludağ. Aigilos 4 does not work; it cannot see any of the Samos sites, although it can see Uludağ.⁵⁸ While Aschoff misreads Louis Bréhier's account of the telegraph as arguing for an extra relay in the Eskişehir area, such an additional beacon would make transmitting the signal over this section of the line much easier.⁵⁹

Since the attempts to locate Aigilos were premised on the Hill of St. Mamas beacon being located on the eastern slopes of Uludağ, the next location, Kyrizos, can now be examined. Belke suggests that Kyrizos might be identified with either Katırlı Dağı or Kurban Dağı. Katırlı Dağı is a flat, wooded hill at 695 m elevation and commands decent views to the north and south. Kurban

Dağı is situated between İznik Gölü and the Sea of Marmara and rises to about 1275 m. The viewshed taken from the top is expansive: Pharos on the sea walls of Constantinople falls inside despite being 74 km distant.

The next beacon, Mokilos, is suggested by Belke to have been Samanlı Dağ.⁶⁰ The viewshed from there can see both Kyrizos as well as Uludağ. Mokilos has limited visibility of its immediate surroundings but can see extensively over the Gulf of Nikomedeia and the Sea of Marmara. Notably, it cannot see Katırlı Dağı, which likely rules out that location for Kyrizos.

The final transmitting beacon was on the Hill of St. Auxentios, which Belke identifies with Kayış Dağı.⁶¹ Once again, this identification can be confirmed, with the hill able to see Mokilos and Pharos. The viewshed from Pharos, taken with a 30 m elevation, is similar (Fig. 5). It can see the Hill of St. Auxentios, Mokilos, the western Kyrizos site, and the Hill of St. Mamas.

At this stage, a few conclusions can be drawn from the experiment. The first and most significant is that an

58 Aschoff, *Feuertelegraphen*, 11–12; Pattenden, “Early Warning,” 297; L. Bréhier, *Les institutions de l'Empire byzantine* (Paris, 1949), 332.

59 Aschoff, *Feuertelegraphen*, 12; Pattenden, “Early Warning,” 297; Bréhier, *Les institutions*, 332.

60 Belke, *Bithynien*, 2:787. Constantine VII indicates that it was above (ἐπάνω) Pylai, which supports this: Constantine VII, *Text C* 132.624–25 (Haldon, *Three Treatises*, 132).

61 Belke, *Bithynien*, 1:438–41.

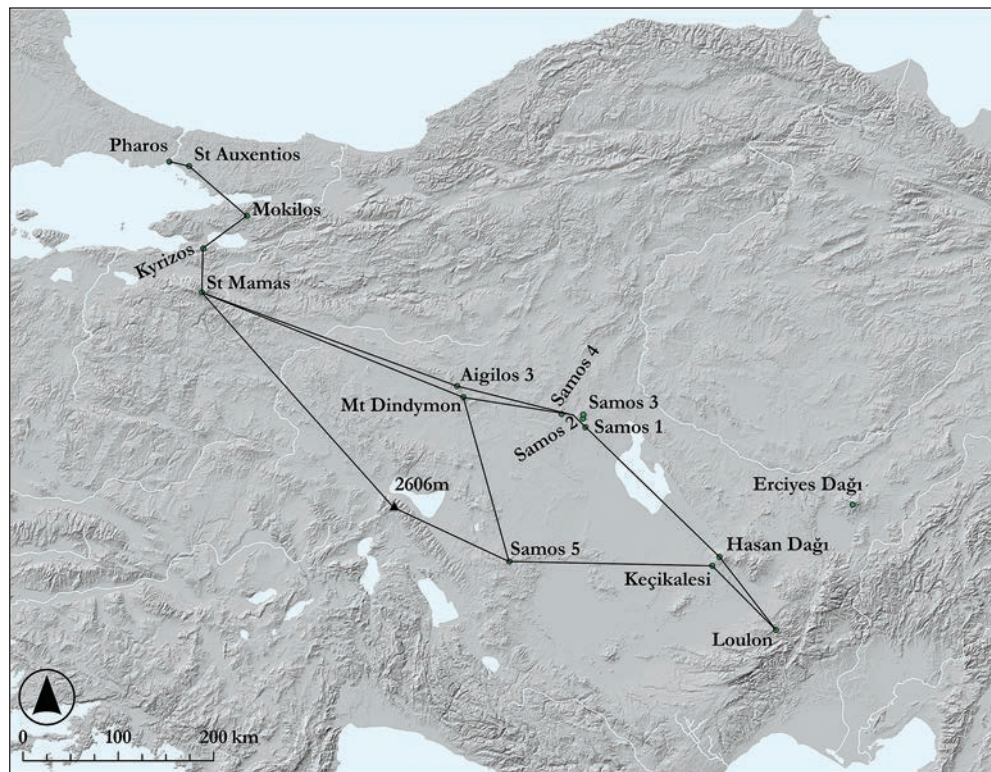


Fig. 6. Summary of functional routes. Map by the author.

Table 1. Summary Table of Routes

Route	Distance (km)
Loulon–Keçikalesi–Samos 5–Hill 2606m– St. Mamas–Kyrizos–Mokilos–St. Auxentios–Pharos	737
Loulon–Hasan Dağı–Samos 1 through 4–Dindymon– St. Mamas–Kyrizos–Mokilos–St. Auxentios–Pharos	716
Loulon–Hasan Dağı–Samos 1 through 4–Aigilos 3– St. Mamas–Kyrizos–Mokilos–St. Auxentios–Pharos	730
Loulon–Keçikalesi–Samos 5–Dindymon–St. Mamas– Kyrizos–Mokilos–St. Auxentios–Pharos	765

eight-beacon chain could have stretched 700 km across Anatolia from the Tauros range to Constantinople (Fig. 6). Four possible routes have been identified (Table 1).

Logistics and Timings

The viewshed analysis indicates that Central Anatolia can in theory be bridged by a small number of beacons. However, the extreme distances between beacon sites raise questions about practicality, and the functional

viewsheds, when merged together, are much less dense than the eastern and western ends and consequently show the difficulty in bridging the gap between Samos and St. Mamas (Fig. 7). The Byzantine beacon chain is clearly an outlier. None of the suggested routes can avoid a single interval greater than 100 km (see Appendix). Good atmospheric conditions were required.⁶² The need

62 The viewsheds taken above account for the curvature of the Earth and refractivity. Atmospheric composition also matters: pre-industrial

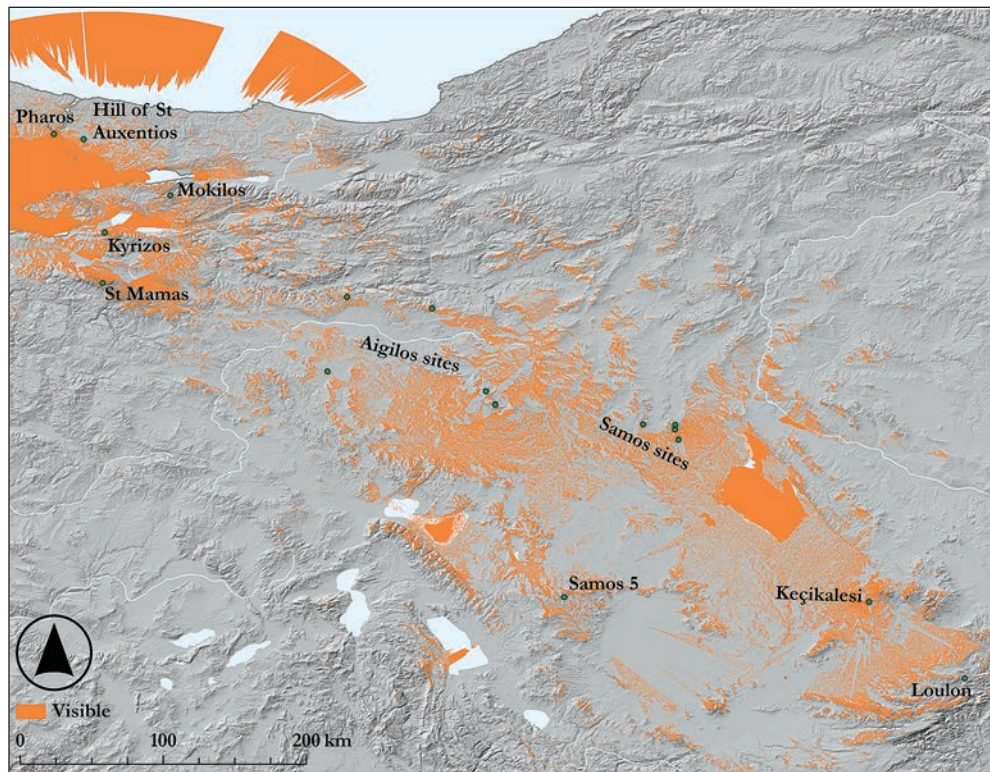


Fig. 7.
Merged viewsheds.
Map by the author.

of the system to operate quickly strongly suggests that it could only have worked at night.⁶³ waiting for a smoke signal is much too slow for the message to arrive in Constantinople in one hour. Moreover, humidity affects refractivity; Aschoff suggests that visibility ranges in the Marmara region should be reduced to approximately 40 percent of their original value.⁶⁴ A similar situation may apply to Tuz Gölü; if refractivity reduced visibility even to 60 percent, Keçikalesi may not always have been visible from the northern Samos sites. All of this raises questions about the practicality of the beacon chain.

levels of CO₂ during the last millennium were in the high 200 parts per million (ppm): J. Ahn et al., "Atmospheric CO₂ over the Last 1000 Years: A High-Resolution Record from the West Antarctic Ice Sheet (WAIS) Divide Ice Core," *Global Biogeochemical Cycles* 26 [2012]: GB2027. Laboratory experiments have demonstrated that atmosphere with more than 300 ppm of CO₂ affects the refractivity of light: K. P. Birch and M. J. Downs, "The Results of a Comparison between Calculated and Measured Values of the Refractive Index of Air," *Journal of Physics E: Scientific Instruments* 21.7 (1988): 694–95.

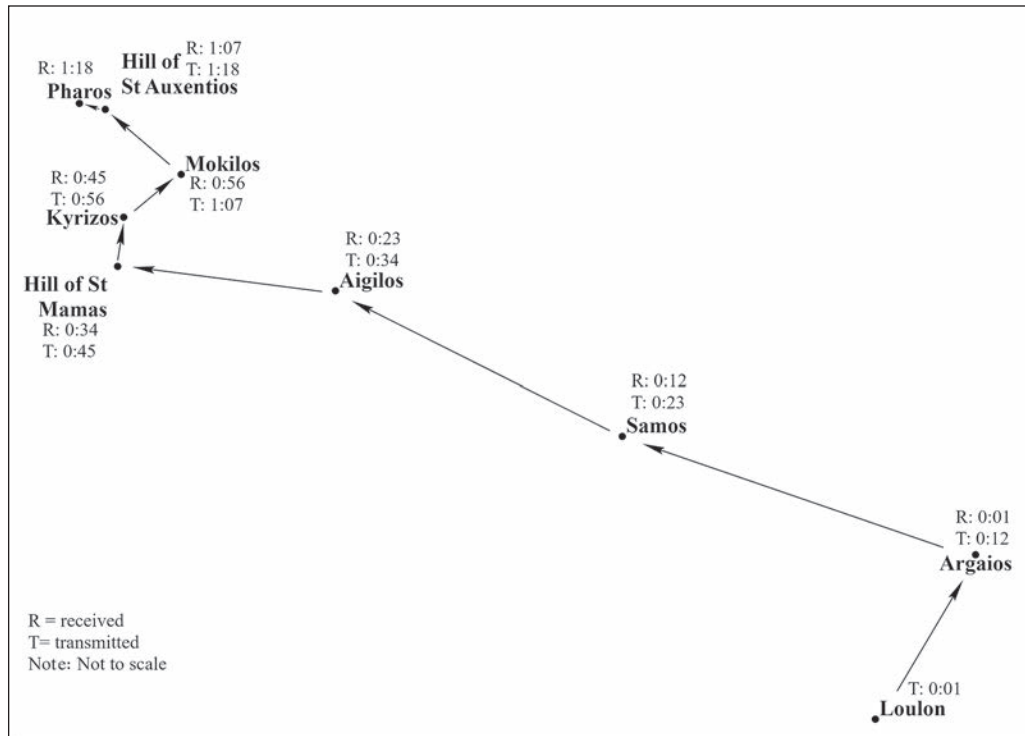
63 L. Montagnini, "Leone il matematico: Un anello mancante nella storia della scienza," *Studi sull'Oriente cristiano* 6.2 (2002): 89–108, at 103.

64 Aschoff, *Feuertelegraphen*, 17.

For a message to arrive in one hour, seven stations needed to light fires. Assuming Loulon lit their fire at the beginning of the hour and that message was received instantly at the first beacon, each station had about eight minutes to get their fire going (Fig. 8). Pattenden's explanation of how the Loulon–Constantinople beacon chain could work argued that an hour was not, in fact, an hour. The difference in longitude between Constantinople and Loulon puts the capital twenty-two minutes behind Loulon, so a message dispatched via the beacon system from Loulon would actually have taken eighty-two minutes.⁶⁵ The longitudinal difference means that assuming that the fire was lit at Loulon upon

65 Pattenden, "Early Warning," 282–85; Montagnini, "Leone il matematico," 101. While the longitudinal difference between Constantinople and Loulon is evident, Pattenden did not attempt to factor in latitude, something Leon would have been aware of: J. Lempire, *Le commentaire astronomique aux Tables Faciles de Ptolémée attribué à Stéphanos d'Alexandrie* (Louvain-la-Neuve, 2016), 301–2. As latitude affects the length of the day, such a difference could affect the synchronization of the clocks, assuming they were calibrated using the sun. A series of tests across the seasons using the National Oceanic and Atmospheric Administration's solar calculator (<https://gml.noaa.gov/grad/solcalc/>) indicate that the difference is minuscule.

Fig. 8.
Summary of timings.
Figure by the author.



the striking of the hour, each beacon station would thus have slightly more than ten minutes to get its fire lit to a sufficient size that it could be seen. The synchronicity of the two clocks was imperative for the system to work. That the system was operating at all suggests that the longitudinal time differential was part of the design.⁶⁶

However, even the extra time leaves little room for error, and the fires would need to be ignited quickly.⁶⁷ This was a tall order, as many of these fires needed to be huge. Some sort of accelerant seems likely, although the sources unfortunately provide no direct evidence. Pattenden suggests naphtha might have been employed.⁶⁸ Wood is less prevalent on the Anatolian plateau, and dung was at times used as fuel.⁶⁹ Syrianos

mentions wood, reeds, branches, grass, or hemp as fuel for beacons but also envisages communications within ranges sufficiently short that they can take place during the day, noting that hemp produces a fierce flame but also dense smoke.⁷⁰ A near-contemporary reference from the Abbasid Caliphate includes naphtha torches alongside banners and drums, evidently for short-range signaling.⁷¹ In another case, the caliph al-Mutawakkil (r. 847–861) dispatched naphtha and olive oil rather than wax to stations along the hajj route, presumably intended for illumination.⁷²

⁶⁶ Montagnini, “Leone il matematico,” 101–3.

⁶⁷ Syrianos Magister, *Peri strategias* 8 (Dennis, “Anonymous Byzantine Treatise,” 26), emphasizes that beacon minders need to be quality troops and presumably men more vigilant than the Armenian border watchers (βήλται) whose indiscipline is bemoaned by Nikephoros II Phokas, *De velitatione bellica* 1 (G. T. Dennis, ed. and trans., “Skirmishing,” in *Three Treatises*, 143–239, at 152).

⁶⁸ Pattenden, “Early Warning,” 280–82.

⁶⁹ Leo of Synada, *Epistulae* 43 (M. P. Vinson, ed. and trans., *The Correspondence of Leo, Metropolitan of Synada*, CFHB 23 [Washington, DC, 1985], 68–70). Leo of Synada’s letters as a source for

environmental history should be used with caution: N. Tsivikis et al., “Reconstructing the Wine Industry of Byzantine Amorium: Production and Consumption of Wine in Central Asia Minor, Seventh to Ninth Centuries,” *DOP* 77 (2023): 131–76, esp. 132–33.

⁷⁰ Syrianos Magister, *Peri strategias* 8 (Dennis, “Anonymous Byzantine Treatise,” 26).

⁷¹ Abū Jaʿfar Muḥammad ibn Jarīr al-Ṭabarī, *The History of al-Ṭabarī*, vol. 33, *Storm and Stress along the Northern Frontiers of the Abbasid Caliphate*, trans. C. E. Bosworth (New York, 1991), 55–56.

⁷² Abū Jaʿfar Muḥammad ibn Jarīr al-Ṭabarī, *The History of al-Ṭabarī*, vol. 34, *Incipient Decline*, trans. J. L. Kraemer (New York, 1989), 190. Contemporary rulers in Europe similarly provided illumination for religious purposes: P. Fouracre, “Lights, Power and

The employment of some form of accelerant becomes more plausible given the short time needed to light the fires, and naphtha is a likely candidate given its use elsewhere. Even with this, however, the chain remained fragile. The extra time provided by the longitudinal difference only affords each station a few extra minutes, and the whole system runs so tightly against the clock that a fire failing to start quickly or a watchman asleep at his job would mean that the entire chain would either fail to send a message at all or send the wrong message. Why then create something so fragile and unlikely to succeed in delivering the correct message? One possibility is that the timing was more generous than has been assumed. Constantine VII explicitly stated that the message arrived in one hour.⁷³ Constantine or one of his secretaries may have read *ῥα* in its regular meaning of “hour” when in this case it only specified the grades marked out on the measuring sticks on the synchronized clocks. Pseudo-Symeon only recorded four possible messages but mentioned twelve possibilities, clearly implying that he similarly understood *ῥα* as a unit of time.⁷⁴ If the four messages he recorded are the complete list rather than a sample, then it is possible that one *ῥα* in the system was actually more like three hours chronologically. This is by no means certain and requires the tenth-century sources to have misunderstood their material, but needs at least to be entertained as a possibility given that the beacon chain would always have operated with a high risk of failure.

Constantinople and Baghdad

If it worked as described, the beacon system was a technical marvel that cleverly used longitude and reveals a deep understanding of the topography of Anatolia. Yet it was complex, able to transmit only a single bit of information, and by bypassing the major military bases did not seem able to bring intelligence to those who would be best placed to act upon it quickly. Moreover, fuel consumption would have been high, and the long-distance sections are weak links in the chain: poor

visibility could sever the connection, or an inattentive crew could easily result in the wrong message being sent. Although a twelfth-century romanticized vision of an earlier era of Arab-Byzantine warfare, in the romance *Digenis Akrites* beacons are lit to summon troops, but no one comes.⁷⁵ No reason is given as to why, but the failure of such a chain was evidently imaginable. These complications and limitations may explain the brief life of the system, but the logistics and physical environment alone do not explain why it was built or what was communicated beyond the intended range of messages and to whom.⁷⁶

The date of the establishment of the beacon system is unclear, but Loulon must have been back under Byzantine control. Al-Ma'mūn attacked the fortress during his 830 and 832 campaigns, which were the first serious attempts at eliminating the Byzantine state in more than a century.⁷⁷ During this time, it may have changed hands several times and received further work

75 *Digenis Akrites*, Grottaferrata 6.361–63, Escorial 1342–47 (E. Jeffreys, ed. and trans., *Digenis Akritis: The Grottaferrata and Escorial Versions* [Cambridge, 1998], 172, 338).

76 On concepts of the frontier and its organization, see A. D. Beihammer, “The Byzantine-Muslim Frontier from the Arab Conquests to the Arrival of the Seljuk Turks,” in *The Islamic-Byzantine Border in History: From the Rise of Islam to the End of the Crusades*, ed. D. G. Tor and A. D. Beihammer (Edinburgh, 2023), 33–70; A. Vacca, *Non-Muslim Provinces under Early Islam: Islamic Rule and Iranian Legitimacy in Armenia and Caucasian Albania* (Cambridge, 2017), 79–82.

77 Abū Ja'far Muḥammad ibn Jarīr al-Ṭabarī, *The History of al-Ṭabarī*, vol. 32, *The Reunification of the 'Abbāsid Caliphate*, trans. C. E. Bosworth (New York, 1987), 185–225, esp. 194. The Arab effort at conquering Constantinople is traditionally seen as having been delayed into an eschatological future after the failure of the siege of 717/718: A. Borrut, *Entre mémoire et pouvoir: L'espace syrien sous les derniers Omeyyades et les premiers Abbassides* (v. 72–193/692–809) (Leiden, 2011), 265–83; K. Y. Blankinship, *The End of the Jihād State: The Reign of Hishām ibn 'Abd al-Malik and the Collapse of the Umayyads* (Albany, NY, 1994), 32–34. However, al-Ma'mūn appears to have seen himself as part of that future and made efforts to destabilize Byzantium by treating with the Bulgars and supporting a major rebellion before the caliph relocated to Syria and embarked on his military campaigns. See H. Yücesoy, *Messianic Beliefs and Imperial Politics in Medieval Islam: The 'Abbāsid Caliphate in the Early Ninth Century* (Columbia, SC, 2009), 109–14, but also a neglected passage by the Armenian historian Movses Kalankatuaci (Daskhurants'i) that mentions a fleet that had been built to attack Constantinople: Movses Daskhurants'i, *The History of the Caucasian Albanians*, trans. C. J. F. Dowsett (London, 1961), 216.

the Moral Economy of Early Medieval Europe,” *EME* 28.3 (2020): 367–87.

73 Constantine VII, *Text C* 132.615 (Haldon, *Three Treatises*, 132).

74 Pseudo-Symeon, *Chronographia* Michael and Theodora 46 (Bekker, *Symeon Magister*, 681–82). Translation in Pattenden, “Early Warning,” 259.

on its fortifications by Theophilos in 831.⁷⁸ Al-Ma'mūn's campaign in 833 ended at Podandos with the death of the caliph, at which point Loulon was likely back in Byzantine hands.⁷⁹ Leon was made archbishop of Thessaloniki in 840 and deposed as an iconoclast after 843, so the system had to predate this.⁸⁰ Moreover, Leon was likely already known for his learning, which he had apparently obtained in the mountains near Thessaloniki and on the island of Hyatros.⁸¹ While for chronological reasons Theophanes Continuatus cannot be entirely trusted on the detail that it was al-Ma'mūn who tried to headhunt Leon, Leon's uncle (and future patriarch of Constantinople, r. 837–843), John the Grammarian, headed an embassy to Baghdad in 830, and this is a plausible means for the caliph to have heard of Leon.⁸² The

selection of Loulon as the departure point for the beacon fire was not innocent—it was a trophy won after repeated struggle.

That such a system was able to be designed when it was does not seem to be a coincidence: allegedly, a certain Stephen the Astrologer came from “Persia” to Constantinople in the later eighth century, and there made corrections and adaptations to Ptolemy's tables of longitude.⁸³ These tables had already been updated in the seventh century by another Stephen, this one from Alexandria, who reoriented them around Constantinople.⁸⁴ Ptolemy's famously flawed calculation of longitude does not apply equally to all places, and the eastern Mediterranean is one of the more accurate zones.⁸⁵ Not only were improvements being made to the ancient understanding of the globe in Byzantium at a time just prior to the establishment of the beacon system, but the ancient material alone may well have been sufficient to make the chain work. Moreover, the beginnings of the “Macedonian Renaissance” as started by the Amorion emperors was underway under the patronage of Theophilos and Michael III, and Leon was an instrumental figure in this and had a notable interest in astronomy.⁸⁶ This “Amorian Renaissance” has its origins in the emperors of the second Iconoclasm (814–842), who recruited learned men from outside of the old educated class to manage the empire and justify their theological position.⁸⁷ Leon's career began around the

78 Signes Codoñer, *Theophilos and the East*, 224–35; cf. W. Treadgold, *The Byzantine Revival, 780–842* (Stanford, CA, 1988), 278–79.

79 Signes Codoñer, *Theophilos and the East*, 233, 242–43; J. P. Turner, “The Death of al-‘Abbās b. al-Ma'mūn and a ‘Thwarted’ Coup d’État,” *JNES* 72.1 (2013): 11–23, at 12–14; al-Ṭabarī, *The History*, 32:194. Unfortunately, pseudo-Symeon, otherwise chronologically precise for the reign of Theophilos, places the entire description of the beacon system in the less-accurate material on Michael III: W. Treadgold, “The Chronological Accuracy of the *Chronicle* of Symeon the Logothete for the Years 813–845,” *DOP* 33 (1979): 157–97, at 190–93.

80 On Leon in Thessaloniki, see Montagnini, “Leone il matematico,” 99, 106; V. Laurent, “Une homélie inédite de l'archevêque de Thessalonique Léon le philosophe sur l'Annonciation (25 mars 842),” in *Mélanges Eugène Tisserant*, vol. 2 (Vatican City, 1964), 281–302. F. Acerbi, “Composition and Removal of Ratios in Geometric and Logistic Texts from the Hellenistic to the Byzantine Period,” in *Revolutions and Continuity in Greek Mathematics*, ed. M. Sialaros (Berlin, 2018), 131–88, at 156–59, is skeptical of Leon's mathematical achievements.

81 Theophanes Continuatus, *Chronographia* 4.27 (Featherstone and Signes Codoñer, *Chronographiae*, 268–70); on educational centers scattered throughout the empire, see Montagnini, “Leone il matematico,” 93–94. Past scholarship has put Leon on Andros, but the critical edition of Theophanes Continuatus reads Hyatros: Theophanes Continuatus, *Chronographia* 4.29 (Featherstone and Signes Codoñer, *Chronographiae*, 272, line 5). For islands as potential repositories of wisdom and the sacred, see K. Ilko, “‘Where the Wild Things Are’: The Medieval Augustinian Order's Perception of Nature between Tree Lore and Environmental History,” *EHR* 139.601 (2024): 1359–88, esp. 1381–88.

82 Theophanes Continuatus, *Chronographia* 4.27 (Featherstone and Signes Codoñer, *Chronographiae*, 262–70); P. Magdalino, “The Road to Baghdad in the Thought-World of Ninth-Century Byzantium,” in *Byzantium in the Ninth Century: Dead or Alive?*, ed. L. Brubaker (Aldershot, 1998), 195–213, at 196–99. For the date,

see Treadgold, “Symeon the Logothete,” 177; C. Erismann, “John the Grammarian and Photius: A Ninth-Century Byzantine Debate on Depiction, Visual Perception and Verbal Description,” *JÖB* 70 (2020): 67–87, at 69; Treadgold, *Byzantine Revival*, 307–8.

83 A.-L. Caudano, “Astronomy and Astrology,” in *A Companion to Byzantine Science*, ed. S. Lazaris (Leiden, 2020), 202–30, at 212.

84 Caudano, “Astronomy and Astrology,” 208–9. The traditional dating and identification of the Stephens is dubious: J. Glynias, “Reconstructing Middle Byzantine Arabo-Greek Astrology from Later Greek Manuscripts,” *Mediterranea* 7 (2022): 183–224, at 190–96.

85 D. A. Shcheglov, “The Error in Longitude in Ptolemy's *Geography* Revisited,” *Cartographic Journal* 53.1 (2016): 3–14.

86 Wilson, *Scholars of Byzantium*, 80–86. Lemerle, *Byzantine Humanism*, 171–204, largely accepts Theophanes Continuatus's account of Leon's career. For a critical, art historical appraisal of the “Macedonian Renaissance,” see J. Hanson, “The Rise and Fall of the Macedonian Renaissance,” in *A Companion to Byzantium*, ed. L. James (Chichester, 2010), 338–50.

87 W. Treadgold, “The Revival of Byzantine Learning and the Revival of the Byzantine State,” *AHR* 84.5 (1979): 1245–66, at 1254–66.

time Ptolemy's *Almagest* was first translated into Arabic in 827.⁸⁸ This was part of a broader turn among astronomers in Abbasid Baghdad toward Greek materials, having exhausted what was available in Middle Persian.⁸⁹ Efforts were made under the caliph al-Ma'mūn to measure the circumference of the Earth and improve upon Ptolemy, but the results remained inaccurate and a second attempt was ordered.⁹⁰ This was probably for the creation of a world map, which does not survive but appears to have been based on Ptolemaic principles.⁹¹ Under al-Wāthiq (r. 842–847), the court astronomer Muḥammad b. Mūsā al-Khwārizmī revised Ptolemy's calculations and coordinate projections. Less than a generation later, the statesman and geographer Ibn Khurrādādhbih not only adapted Ptolemy to place Iraq at the center of the world, but in the same work made

extensive use of Abbasid administrative geography.⁹² Ibn Khurrādādhbih included measurements such as the number of stops between postal (*barīd*) stations and provincial tax revenues. While the evidence from the intermittent stages is lost, surviving manuals demonstrate sophisticated Byzantine understanding of land surveying, both for taxation and for the use of the army.⁹³ Such practical skills were employed by both empires to bring in revenue, perform construction, and generally manage their realms. This mundane knowledge was put to work here for more abstract objectives in imperial cosmology in the construction of the beacon system, as well as for the Abbasid world-measuring projects. A further element of competition is evident in the narrative being created in ninth-century Baghdad about how the Romans had turned their backs on Greek science and thus the Arabs were the true inheritors.⁹⁴ Yet this narrative would be less necessary if Constantinople were not engaging with the ancient heritage, and that is in fact exactly what we see: ninth-century Byzantine intellectuals were reaffirming Roman-ness in light of Islam, and this involved interacting with ancient Greek texts.⁹⁵ Meanwhile, intellectual communication with the Islamic world was also taking place: the Quran was translated into Greek, and Islamic art and architecture inspired Byzantine imitations.⁹⁶ Theophilus constructed a suburban palace

88 D. Gutas, *Greek Thought, Arabic Culture: The Graeco-Arabic Translation Movement in Baghdad and Early 'Abbāsī Society (2nd–4th/8th–10th Centuries)* (London, 1998), 114; M. Mavroudi, "Byzantine Translations from Arabic into Greek: Old and New Historiography in Confluence and in Conflict," *Journal of Late Antique, Islamic and Byzantine Studies* 2.1–2 (2023): 215–88, at 227–31. Astrological materials were being translated into Arabic from the beginning of the Abbasid era, but this early interest seems more focused on horoscopes and portents: D. Pingree, "From Alexandria to Baghdad to Byzantium: The Transmission of Astrology," *International Journal of the Classical Tradition* 8.1 (2001): 3–37, at 3–21. For ninth-century intellectuals, astronomy, and relations with Baghdad, see P. Magdalino, *L'orthodoxie des astrologues: La science entre le dogme et la divination à Byzance, VII^e–XIV^e siècle* (Paris, 2006), 62–67. Leon was rewarded with the position of bishop of Thessaloniki in 840 but was deposed as an iconoclast following the Triumph of Orthodoxy in 843: Montagnini, "Leone il matematico," 106. The date of Leon's death is unknown, but he was commemorated in the following century as an exceptionally learned man in an epitaph by Leon Choïrosphaktes, who himself had a notable interest in astronomy: Leon Choïrosphaktes, *Poèmes inédits* 4 (G. Kolias, ed., *Léon Choërosphactès, magistre, proconsul et patrice* [Athens, 1939], 132). Among the correspondence of Choïrosphaktes is a letter from the Bulgar khagan Symeon acknowledging the recipient's astronomical skills: Leon Choïrosphaktes, *Epistulae* 1 (G. Strano, ed. and trans., *Corrispondenza: Introduzione, testo critico, traduzione e note di comment* [Catania, 2008], 42).

89 Gutas, *Greek Thought*, 108–10. Many of the books need not have come from Byzantium: F. Acerbi and M. Trizio, "Uprooting Byzantium: Ninth-Century Byzantine Books and the Graeco-Arabic Translation Movement," *Scandinavian Journal of Byzantine and Modern Greek Studies* 8 (2023): 105–54, esp. 109–35.

90 M. Cooperson, *Al-Ma'mūn* (Oxford, 2005), 89–91.

91 A. Nazmi, "'Al-Hārīta al-Ma'mūniyya': The Islamic World Map of al-Ma'mūn and the Islamic Cartography," *Rocznik Orientalistyczny* 57.1 (2004): 77–94.

92 T. Zadeh, *Mapping Frontiers across Medieval Islam: Geography, Translation and the 'Abbasid Empire* (London, 2011), 24–27.

93 J. Lefort et al., ed., *Géométries du fisc byzantine* (Paris, 1991); Nikephoros II Phokas, *De velitatione bellica* 13 (Dennis, "Skirmishing," 188–90).

94 Gutas, *Greek Thought*, 83–95; N. M. El Cheikh, *Byzantium Viewed by the Arabs* (Cambridge, MA, 2004), 103–11. The competition extended beyond intellectual matters and included demonstrations of martial valor, e.g., Theophanes Continuatus, *Chronographia* 3.23 (Featherstone and Signes Codoñer, *Chronographiae*, 164–66). Sypiański's point that Abbasid philhellenism equals anti-Byzantinism is well-placed: J. Sypiański, "Arabo-Byzantine Relations in the 9th and 10th Centuries as an Area of Cultural Rivalry," in *Βυζάντιο και Αραβικός κόσμος: Συνάντηση Πολιτισμών / Byzantium and the Arab World: Encounter of Civilizations*, ed. A. Kralides and A. Gkoutzioukostas (Thessaloniki, 2013), 465–78, at 470.

95 J. Haldon, "Eastern Roman (Byzantine) Views on Islam and on Jihād, c. 900 CE: A Papal Connection?," in *Italy and Early Medieval Europe: Papers for Chris Wickham*, ed. R. Balzaretti, J. Barrow, and P. Skinner (Oxford, 2018), 476–85, at 481–83.

96 Haldon, "Eastern Roman (Byzantine) Views on Islam," 481–85; A. Ricci, "The Road from Baghdad to Byzantium and the Case of the Bryas Palace in Istanbul," in Brubaker, *Byzantium in the Ninth*

in the Abbasid style, and his setting up automata in the Magnaura has been interpreted as an attempt at establishing physical reminders of Byzantine success against Islam, no matter how minor those real successes may have been.⁹⁷ The automata may have been inspired by or imported from Baghdad, and a later source even attributes their construction to Leon the Mathematician.⁹⁸ Moreover, this went both ways—when a Byzantine embassy arrived to the court of al-Hādī (r. 785–786), al-Ṭabarī claimed that the caliph ordered one of his courtiers to remove his hat to expose his bald head and so present the appearance of sagacity.⁹⁹ A similar process of mapmaking and sponsoring learning that made use of the classical past in the name of imperial ideology was underway in the court of Charlemagne (r. 768–814) near the end of his life.¹⁰⁰ That the Frankish, Abbasid, and Byzantine courts were all sponsoring intellectual efforts that hearkened back to the classical past in order to justify universal imperial claims in the present is too much of coincidence. The embassies that passed between Baghdad, Constantinople, and Aachen undoubtedly helped move such ideas about. Carolingian-Abbasid exchanges have recently been described as “prestige diplomacy,” where the dispatch and receipt of distant envoys served to bolster the monarch’s position at home.¹⁰¹ Exchange of ambassadors between Constantinople and Baghdad was more frequent, and they show how intellectual and religious debates were related to broader cosmological questions of empire.

While intellectual debates were taking place over claims to the heritage of ancient Greece, religious

discussions were also ongoing. Niketas Byzantios, one of the foremost intellectuals of the ninth century, engaged in polemics against Islam as well as against the Armenians and the addition of the *filioque* to the Nicene Creed by the Western church.¹⁰² In contrast to predecessors such as John of Damascus, he applied Aristotelian logic in his work.¹⁰³ Niketas made an effort to engage the Arabs on common ground, and it is notable that he was using these techniques at precisely the time when similar principles were being employed in high-level discussions at the Abbasid court over the use of reason in religious debate. In this way, Niketas was both claiming Aristotle and arguing that Christianity was not illogical, an opinion supported by some Arab intellectuals.¹⁰⁴ Greek sources rarely let on about education in foreign languages in Byzantium, but an enigmatic reference from a generation later plausibly suggests an imperial granddaughter was receiving lessons in the Arabic language.¹⁰⁵ The Abbasids and Byzantines were engaged in competition tinged with an intellectual element: manuscripts were valuable diplomatic gifts, many ambassadors were learned men, and embassies involved displays of mental and cultural prowess.¹⁰⁶ Despite ongoing antagonism, the elite in both the Byzantine and Abbasid worlds nonetheless shared a sufficiently common referential framework to permit such competition.¹⁰⁷

First, the story about the coming of Leon to Theophilos’s court, suspect as it is, makes a direct connection to competition with Baghdad over intellectuals. Theophanes Continuatus specifically claims that the Abbasids were headhunting Leon.¹⁰⁸ Seeking out

Century, 131–49; R. G. Ousterhout, *Eastern Medieval Architecture: The Building Traditions of Byzantium and Neighboring Lands* (New York, 2019), 365, n. 23.

97 H. Keshani, “The ‘Abbāsid Palace of Theophilus: Byzantine Taste for the Arts of Islam,” *Al-Masāq* 16.1 (2004): 75–91, at 77–86. The palace was probably built in 837: Treadgold, “Symeon the Logothete,” 178.

98 G. Brett, “The Automata in the Byzantine ‘Throne of Solomon,’” *Speculum* 29.3 (1954): 477–87, at 482–83; Montagnini, “Leone il matematico,” 104–5.

99 Abū Jaʿfar Muḥammad ibn Jarīr al-Ṭabarī, *The History of al-Ṭabarī*, vol. 30, *The ‘Abbāsid Caliphate in Equilibrium*, trans. C. E. Bosworth (New York, 1989), 66.

100 R. McKitterick, *Charlemagne: The Formation of a European Identity* (Cambridge, 2008), 372–77.

101 S. Ottewill-Soulsby, *The Emperor and the Elephant: Christians and Muslims in the Age of Charlemagne* (Princeton, 2023), 114–46.

102 Niketas is no longer believed to have translated the Quran into Greek: M. Ulbricht, “The Authorship of the Early Greek Translation of the Quran (Vat. gr. 681),” *DOP* 77 (2023): 221–43; Mavroudi, “Byzantine Translations,” 252–53.

103 C. Erisman, “Common Notions and Rational Arguments: Nicetas of Byzantium’s Logical Arsenal and Ninth-Century Byzantine Polemic against Islam,” *Journal of Eastern Christian Studies* 72.3–4 (2020): 273–90, at 277–89.

104 Erisman, “Common Notions,” 285–89.

105 H. Taghavi, E. Roohi, and N. Karimi, “An Ignored Arabic Account of a Byzantine Royal Woman,” *Al-Masāq* 32.2 (2020): 185–201, at 189–92.

106 Sypiński, “Arabo-Byzantine Relations,” 465–74.

107 Mavroudi, “Byzantine Translations,” 277–78; El Cheikh, *Byzantium Viewed by the Arabs*, 2–3, 88–89, 101–11.

108 Theophanes Continuatus, *Chronographia* 4.27 (Featherstone and Signes Codoñer, *Chronographiae*, 262–70).

knowledge in foreign lands was not unheard of. After the director of the so-called House of Wisdom, the caliphal library in Baghdad, made an effort to improve the translation of Ptolemy's *Almagest*, he was dispatched to Byzantium by al-Ma'mūn on a mission to acquire Greek books.¹⁰⁹ Moreover, it is difficult not to see this in light of the other prohibitions on prestige exports coming from the pen of Constantine VII, namely, princesses and Greek fire.¹¹⁰ The competition over intellectuals did not just connect the space between Baghdad and Constantinople, but temporal competition linked the ninth- and tenth-century courts in Constantinople over which dynasty contributed to the restoration of intellectual life. The second is that Leon designed a system that required an understanding of longitude. While he could have done this from Stephen of Alexandria's revision of Ptolemy's *Handy Tables*, or perhaps from Ptolemy himself, that the telegraph was designed by Constantinople's best astronomer right when Baghdad's intellectuals were delving into ancient Greek astronomy and the measurement of the circumference of the Earth seems to be too much of a coincidence. While the first efforts at this were made in Sinjar, Iraq, al-Ma'mūn had an observatory installed in Damascus after he had moved his administration there to manage more effectively his campaigns against Byzantium.¹¹¹ Among the works ascribed to Ḥabash ibn 'Abd Allāh al-Marwazī al-Ḥāsib by al-Nadīm are the *Damascus Astronomical Table* and the *Ma'mūni Astronomical Table*, linking him both to al-Ma'mūn's interests and the war.¹¹² Al-Ma'mūn's final attempt at taking the measurements was carried out on the Byzantine frontier in Cilicia and the same general area as the beacon system's first post.¹¹³ Michael Cooperson has taken al-Ma'mūn's attempts to continue to measure

the Earth while on campaign against Byzantium as evidence of the caliph's overriding intellectual interests; this may well be true, but it was also part of another arena of conflict with Byzantium.¹¹⁴ The astronomer Yaḥyā ibn Abī Maṣṣūr reportedly calculated the latitude of Baghdad during al-Ma'mūn's reign and may have gone on campaign with the caliph, since he reportedly died in Byzantine territory.¹¹⁵

Al-Ma'mūn in particular sought ancient knowledge that would provide insight into the pure monotheistic faith that predated Judaism and Christianity and that Islam had restored; all peoples would submit to the Mahdi, a role that al-Ma'mūn may have envisaged himself in.¹¹⁶ Al-Ma'mūn's intellectual program was based on the belief that pre-Islamic ancient sciences had been scattered geographically and linguistically despite sharing a common, divine origin.¹¹⁷ The Mahdi would find these ancient books, and the conflict between the monotheisms would end, with Islam victorious and Constantinople conquered.¹¹⁸ Figures like Hermes, Adam, and Enoch were believed to have received the untainted monotheism, and the Hermetic form of knowledge—such as lost libraries, buried tablets, and ancient manuscripts—is what al-Ma'mūn reportedly sought out.¹¹⁹ Curiously, Leon fits into the narrative of seeking out ancient learning in a range of remote places, namely, the island of Hyatros and the monasteries in the mountains near Thessaloniki.¹²⁰ Leon's success was a challenge to the entire eschatological world of the Abbasid court. Knowledge had been scattered and lost, yet one Roman surpassed all the efforts of the Arabs. Byzantium was the font from which all ancient learning flowed. No direct evidence exists that Abbasid envoys were ever shown any aspect of the beacon chain, but providing diplomatic visitors with curated experiences designed to highlight Byzantine power and prestige had a long history. From the scenes on the base of Theodosios's obelisk in the Hippodrome in late antiquity to Liudprand of Cremona's account of his visits

109 E. İhsanoğlu, *The Abbasid House of Wisdom: Between Myth and Reality* (Abingdon, 2023), 62–64.

110 Constantine VII, *De administrando imperio* 13.73–103 (G. Moravcsik, ed., and R. J. H. Jenkins, trans., *Constantine Porphyrogenitus: De administrando imperio*, CFHB 1 [Washington, DC, 1985], 68–70); Magdalino, "The Road to Baghdad," 196–202.

111 On the Abbasid caliphs and residence in Syria, see Borrut, *Entre mémoire et pouvoir*, 456–66.

112 Abū al-Faraj Muḥammad ibn Ishāq al-Nadīm, *The Fibrist of al-Nadīm: A Tenth-Century Survey of Muslim Culture*, trans. B. Dodge (New York, 1970), 653–54.

113 Cooperson, *Al-Ma'mun*, 89–90; İhsanoğlu, *The Abbasid House of Wisdom*, 6.

114 Cooperson, *Al-Ma'mun*, 91.

115 Al-Nadīm, *Fihrist*, 653.

116 Yücesoy, *Messianic Beliefs*, 113–15.

117 Yücesoy, *Messianic Beliefs*, 116–19.

118 Yücesoy, *Messianic Beliefs*, 121.

119 Yücesoy, *Messianic Beliefs*, 121–25.

120 Theophanes Continuatus, *Chronographia* 4.27 (Featherstone and Signes Codoñer, *Chronographiae*, 268–70).

to Constantinople to Georgios Pachymeres's account of the elaborate stage-managing of the journey of the Mongol envoys to the court of Theodoros II Laskaris in 1256, visiting ambassadors were kept on a tight leash and used for imperial power, prestige, and display.¹²¹ In this context, it is not difficult to imagine visiting envoys from Baghdad being shown the Pharos clock or having the system explained in a general way. In this sense, the beacon chain's theoretical longitudinal underpinnings may well have served their purpose more effectively as a showpiece and as an aspect of Byzantine competition with Abbasid (and Carolingian) cosmological ideas of empire. For this, the telegraph did not need to function perfectly. The near incomprehensibility and high level of mathematics required are features rather than bugs and showcase imperial power controlling ancient knowledge.¹²² An explanation of its general workings no more jeopardized its operational security than showing Greek fire to visiting ambassadors.

Optical Communications and Warfare

Although the beacon chain transmitted only a small amount of information that may not have been particularly useful and was an element of prestige diplomacy, it still served a practical purpose. The first half of the ninth century was a period when caliphs led armies in person. Al-Ma'mūn had solved the troop shortages that plagued his early reign through the recruitment of central Asian elements and was also wintering regularly in Damascus.¹²³ This increased Abbasid mobility and situated a major army near the Tauros frontier. The departure to war of the leader of the most powerful state in western Eurasia was bound to be noticed, and their armies could not be assembled or supplied overnight. While Constantinople might not have had the precise intelligence of where an Abbasid army was going, the Byzantines would know when the caliph and his forces had set out against them through other channels, such

as spies or merchants.¹²⁴ In this sense, the Loulon beacon system has value as a trip wire capable of indicating whether a major army was coming through Cilicia.

The Cilician frontier was where al-Ma'mūn had focused his attention, besieging a number of fortresses, capturing some, and fortifying others.¹²⁵ In 838, the new caliph, al-Mu'taṣim, set off against Anatolia with a large army, possibly out of a desire for revenge for Theophilos attacking Melitene and Sozopetra or perhaps intending to strike a blow both strategic and prestigious by taking the most heavily fortified military center in the empire.¹²⁶ Defense was not an initial concern for al-Mu'taṣim, who ordered the construction work on the fortifications at Tyana stopped and dismantled.¹²⁷ This work had been ordered by al-Ma'mūn but was being carried out by his son al-'Abbas, who remained a rival of al-Mu'taṣim.¹²⁸ The attack on Amorion had a performative element, as refugees had previously streamed into the new caliphal residence in Samarra and reported the brutality of Theophilos's campaign.¹²⁹ During al-Mu'taṣim's 838 campaign, Ankyra and Amorion were sacked and the emperor personally defeated at the Battle of Anzen, although the campaign proved costly for the Abbasids, and the account of their return home suggests fear of a Byzantine counterattack.¹³⁰ Even as a trip wire, the beacons bought the authorities in Constantinople a few extra days in comparison to news arriving via horse relay.

All of this assumes, even when arguing that the military value of the beacon system was marginal, that

121 M. P. Canepa, *The Two Eyes of the Earth: Art and Ritual of Kingship between Rome and Sasanian Iran* (Berkeley, CA, 2009), 111–14; N. Drocourt, *Diplomatie sur le Bosphore: Les ambassadeurs étrangers dans l'Empire byzantin des années 640 à 1204* (Leuven, 2015), 585–634; Georgios Pachymeres, *Historia* 25 (A. Failler, ed., and V. Laurent, trans., *Georges Pachymères: Relations historiques*, vol. 1, CFHB 24 [Paris, 1984], 187–89).

122 Acerbi and Trizio, "Uprooting Byzantium," 141–42.

123 F. Amabe, *The Emergence of the 'Abbāsid Autocracy: The 'Abbāsid Army, Khurāsān and Adharbayjān* (Kyoto, 1995), 135–39.

124 Syrianos Magister, *Peri strategias* 42 (Dennis, "Anonymous Byzantine Treatise," 122–24); N. Koutrakou, "Spies of Towns': Some Remarks on Espionage in the Context of Arab-Byzantine Relations (VII–Xth Centuries)," *Graeco-Arabica* 7/8 (2000): 243–66.

125 Al-Ṭabarī, *The History*, 32:178, 185, 198–99.

126 Signes Codoñer, *Theophilos and the East*, 279–86.

127 Al-Ṭabarī, *The History*, 33:2.

128 Turner, "The Death of al-'Abbās b. al-Ma'mūn," 13–23; al-Ṭabarī, *The History*, 32:198–99.

129 Al-Ṭabarī, *The History*, 33:93–97. Urban unrest following military failure was not unknown in the Abbasid Caliphate, which put caliphs in the position of having to respond to the mob; upon arrival in Baghdad in 863 of news of a major raiding party from Melitene being defeated, riots broke out: Abū Ja'far Muḥammad ibn Jarīr al-Ṭabarī, *The History of al-Ṭabarī*, vol. 35, *The Crisis of the 'Abbāsid Caliphate*, trans. G. Saliba (New York, 1990), 10–11.

130 Al-Ṭabarī, *The History*, 33:118–19; Signes Codoñer, *Theophilos and the East*, 308–10. For the campaign in general, see J. Haldon, *The Byzantine Wars: Battles and Campaigns of the Byzantine Era* (Stroud, 2001), 82–86.

it was designed to deliver information to authorities in Constantinople. The account of Michael III dismantling the telegraph opens the question of audience: Michael shut the system down because the people of Constantinople saw the beacons.¹³¹ This would only be an issue if they had some idea of what it meant. Constantine VII took this further by discussing how in the old days, upon receiving the signal, the emperor would prepare for war by marshaling his troops and going forth to confront the enemy.¹³² While the people would not have had access to the clock to know the precise message, from the perspective of the average citizen of Constantinople the message was clear: violence from the *dar al-Islam*.

Constantine VII criticized Michael through a fictitious quote that the citizens would be distressed and then not be able to see him at his chariot race.¹³³ The story does not quite add up: in it, Michael was about to take part in the chariot race against some of his high officials, at least one of whom was the logothete of the dromos, the postmaster whose responsibilities included bringing intelligence to the capital.¹³⁴ The picture the tenth-century written texts attempt to make is that of an emperor so utterly derelict in his duties that he also compromised the other warning system, the human and animal messengers who ran the dromos and delivered timely information from the frontiers. Aside from the fact that the emperor in a chariot was part of imperial imagery in this period, the raid came from the wrong direction.¹³⁵ News allegedly arrived in Constantinople that 'Amr, the emir of Melitene, was on a raid deep into Anatolia and had reached Malagina, only some 60 km

east of Nikaia.¹³⁶ Melitene, however, is situated far to the northeast of the Cilician frontier. Unless 'Amr had chosen to take the longer, southern route through hardened defenses, a suggestion that seems unlikely given how deep he was able to raid while escaping detection, the beacon system would not have helped. The chain simply did not run in that direction.

Moreover, Dimitris Krallis has proposed that the story has a further level: since the Hippodrome was the model of the polity, the emperor being disturbed there has wider implications for the stability of the empire, and the near-instantaneous arrival of the message means that Romans in the capital and Romans in Cilicia shared in the threat.¹³⁷ Constantinople could move to the frontier.¹³⁸ This point is well-taken and reinforces the need for security theater since it obliges the emperor to answer threats to Romans throughout the entire polity, and is analogous to the cases of the caliph responding to news of violence done to Islamic cities by Byzantium. The problem that Michael faced was that the citizens may have been ultimately distressed less by the news of invasion than from seeing their emperor fail to respond to it. Without access to the clock, war could not be distinguished from a raid, and the people of the city would not witness in any notable way the arrival of more detailed military intelligence several days later. Michael did not have to face the aggressive campaigning of al-Ma'mūn and al-Mu'taṣim, and his eastern wars shifted northeast to the Euphrates theater.¹³⁹ If the beacons created an expectation that the emperor perform, then their lighting during much of Michael's reign set an expectation that he would need to respond to the

131 Constantine VII, *Text C* 134.639–46 (Haldon, *Three Treatises*, 134).

132 Constantine VII, *Text C* 134.631–38 (Haldon, *Three Treatises*, 134).

133 Constantine VII, *Text C* 134.643–45 (Haldon, *Three Treatises*, 134).

134 R. Guiland, "Les logothètes: Etudes sur l'histoire administrative de l'Empire byzantin," *REB* 29 (1971): 5–115, at 31–70, esp. 33–38; Fossella, *Dromos and Byzantine Communications*, 87–95.

135 In contrast to this negative textual imagery of the emperor, see the imperial charioteer figure on London, Victoria and Albert Museum, inv. T.762-1892 (silk dating from around 800): L. Brubaker and J. Haldon, *Byzantium in the Iconoclast Era (ca 680–850)* (Aldershot, 2001), 101–2.

136 'Amr (ʿAṣep) was 'Umar ibn 'Abdallāh ibn Marwān al-Aqṭa'. See *PmbZ*, no. 8552; Dixon, *The Paulicians*, 278–97.

137 D. Krallis, "Time, Space, and Physical Reality: Byzantine Authors and the Materiality of the Roman Imagined Community," in *Byzantine Authors and Their Times*, ed. V. N. Vlyssidou (Athens, 2021), 179–98, at 188–89.

138 A. Weller, "Byzantis' as a Movable Quality: Carrying Constantinople into the Frontier Provinces in the 10th–11th Centuries," *BSI* 74.1–2 (2016): 190–201, at 190–95.

139 Theophanes Continuatus, *Chronographia* 4.23–25 (Featherstone and Signes Codoñer, *Chronographiae*, 251–63); Symeon Magister and Logothetes, *Chronicon* 131.26 (S. Wahlgren, ed., *Symeonis Magistri et Logothetae Chronicon*, CFHB 44 [Berlin, 2006], 243–44); al-Tabarī, *The History*, 34:204–9; Dixon, *The Paulicians*, 278–97; K. Durak, "The Economy of Melitene/Malatya and Its Role in the Byzantine-Islamic Trade (Seventh to Eleventh Centuries)," *BZ* 115.3 (2022): 829–74, at 859–72.

threat, but this might be no more than a raid in a secondary theater of war. Raids took place annually and have been characterized as nearly ritualistic, although this interpretation downplays competition over metal resources and the economic benefits that can come from raiding.¹⁴⁰ Regular raiding predated the construction of the optical telegraph by a century, and it is highly unlikely that a new, fragile, and unwieldy communication system was established to deal with annual raiders who came at specific times and through a limited number of routes through the Tauros. Rather, the beacon system's creation can only be linked to direct military competition between emperor and caliph and the renewed Abbasid effort to conquer Byzantium.

While the beacons may have been a form of security theater to a Constantinopolitan audience, they served a practical function at a more local level in the east. The unique position of Keçikalesi means that its beacon would be widely visible in its surrounding region, and its location near a junction of roads immediately north of the Tauros would also have served to spread the news. Military manuals suggest that news of an attack was acted upon: civilians and their portable valuables were to be moved to safe locations, and soldiers were to be marshaled.¹⁴¹ The failure to detect or heed a warning is vividly recounted in the *Miracles of St. Theodore*. The city of Euchaïta in Pontos was occupied over the winter, although the Arabs failed to take the citadel. The *Miracles* recount the death and captivity of many people and animals as well as an attempt to destroy Theodore's shrine.¹⁴² A further miracle recounts an attack against a suburban church at Euchaïta and notes in the third-person plural that "we"

were all staying close to the citadel because of the expectation of the annual raid. This was evidently a good idea, as the congregation was able to escape inside the walls of the fortress.¹⁴³ The use of beacons to summon local troops is clear in *Digenis Akrites*, although the troops fail to show up in a timely manner.¹⁴⁴ In light of this, fire beacon systems were evidently in place for local defense along the eastern frontier and served functional purposes, although they are generally beneath mention in the Constantinopolitan source base. Moreover, they may have had an ideological value, giving provincial citizens a stake in the empire and binding them to the center, as they created an expectation that the authorities respond to threats.¹⁴⁵

A Literary Precedent?

The matter of the distances between beacons across the Anatolian plateau remains a problem: while the experiment conducted above suggests that such a line is not impossible, the line remains problematic for a number of reasons. If more beacon sites existed, outside of error, why might the list not include them? Might there be a *canonical* explanation for the selection of only a choice number of sites? Beacon fires were not unfamiliar to an educated audience since they appear in the classics of ancient Greek literature, many of which made up the educational curriculum in Byzantium.

Fire beacons appear in the *Iliad*, but only in a general sense, and no locations are given.¹⁴⁶ Herodotos reported that Xerxes established a fire beacon system across the Aegean to Sardis to provide information about the fall of Athens.¹⁴⁷ At the beginning of Aischylos's tragedy *Agamemnon*, the eponymous war-leader's queen, Klytaimnestra, is informed by her sentry that Troy has fallen.¹⁴⁸ The elders of Argos wonder how she could know this as well as when the city had been

140 S. W. Merkel, J. Oravisjärvi, and J. Kershaw, "Sources of Early Islamic Silver: Lead Isotope Analysis of Dirhams," *Antiquity* 97.396 (2023): 1564–80, at 1573–76; J. Haldon and H. Kennedy, "The Arab-Byzantine Frontier in the Eighth and Ninth Centuries: Military Organisation and Society in the Borderlands," *ZRVI* 19 (1980): 79–116; A. A. Eger, *The Islamic-Byzantine Frontier: Interaction and Exchange among Muslim and Christian Communities* (London, 2015), 253–84.

141 Leon VI, *Taktika* 17.66 (G. T. Dennis, ed. and trans., *The Taktika of Leo VI*, CFHB 49 [Washington, DC, 2010], 418); Nikephoros II Phokas, *De velitatione bellica* 2.3–10, 8.4–7 (Dennis, "Skirmishing," 152, 164).

142 *Vie et miracles de S. Théodore* 12 (H. Delehaye, *Les légendes grecques des saints militaires* [Paris, 1909], 196–98); J. Haldon, trans., *A Tale of Two Saints: The Martyrdoms and Miracles of Saints Theodore "the Recruit" and "the General"* (Liverpool, 2016), 105–7.

143 *Vie et miracles de S. Théodore* 15 (Delehaye, *Les légendes*, 199–201); Haldon, *Two Saints*, 109–10.

144 *Digenis Akrites*, Grottaferrata 6.361–63, 6.438–54, Escorial 1342–47 (Jeffreys, *Digenis*, 172, 178, 338).

145 Krallis, "Time, Space, and Physical Reality," 189–90.

146 Homer, *Iliad* 18.210–13 (M. L. West, ed., *Homeri Ilias*, vol. 1 [Stuttgart, 1998], 178).

147 Herodotos, *Histories* 9.3.1 (H. B. Rosén, ed., *Herodoti Historiae*, vol. 2 [Leipzig, 1997], 385).

148 Aischylos, *Agamemnon* lines 1–31 (M. L. West, ed., *Aeschyli Agamemnon* [Stuttgart, 1991], 3–4).



Fig. 9.
Beacon chain in
Aischylos,
Agamemnon lines
281–315. Map by
the author.

captured.¹⁴⁹ Klytaimnestra responds that it had fallen that very night and that she knew about it because a series of fire beacons had conveyed this information, and then she proceeds to trace out where each beacon fire had been lit, starting with Mt. Ida near Troy.¹⁵⁰ From Mt. Ida to her palace, she lists nine beacon sites in total (Fig. 9). Aischylos plausibly provided such detail so as to connect for his viewers the destruction of Troy with the fall of Athens in 479 BCE to the Persians.¹⁵¹

Aischylos was often read in Byzantium, with the *Persai*, *Prometheus Bound*, and *Seven against Thebes* forming a core component of the trivium.¹⁵² His tragedies were not read with equal frequency, and

Agamemnon was one of his less popular works.¹⁵³ It was not, however, unknown in learned circles. The *Suda* mentions it under the entry for courier relays, which is a curious reference considering the interest here in the rapid transmission of information.¹⁵⁴ The earliest complete manuscript of all seven of the surviving plays dates to the mid-tenth century.¹⁵⁵ A century prior, Photios alluded to *Prometheus Bound*, confident his reader was familiar with the play, and Leon Choiosphaktes would later make a slip that indicated his knowledge of the same play.¹⁵⁶ In the ninth century, Theodore of Stoudios made a reference to *Agamemnon*

149 Aischylos, *Agamemnon* lines 84–86 (West, *Agamemnon*, 7).

150 Aischylos, *Agamemnon* lines 280–316 (West, *Agamemnon*, 17–19).

151 S. V. Tracy, “Darkness from Light: The Beacon Fire in the *Agamemnon*,” *CQ* 36.1 (1986): 257–60; cf. D. W. Moore, “Proof through the Night: Representations of Fire-Signaling in Greek Historiography,” *Histos* 11 (2017): 108–27, at 110–11, who claims that the system described by Herodotos was a fiction but accepts that Aischylos invokes a beacon system to link the conquest of Troy to the Achaemenid sack of Athens.

152 A. Markopoulos, “Education,” in *OHBS*, 785–95, at 788.

153 C. Simelidis, “Aeschylus in Byzantium,” in *Brill’s Companion to the Reception of Aeschylus*, ed. R. F. Kennedy (Leiden, 2018), 179–202, at 179–83. Moreover, *Agamemnon* is not well represented among Byzantine epigrams deriving from Aischylos: M. Tomadaki and E. van Opstall, “The Tragedians from a Byzantine Perspective: Book Epigrams on Aeschylus, Sophocles and Euripides,” *Medioevo greco* 19 (2019): 193–220, at 195–203.

154 *Suda* A 164 (ἀγγαροί: A. Adler, ed., *Suidae Lexicon*, vol. 1 [Munich, 2001], 21).

155 Simelidis, “Aeschylus in Byzantium,” 183; Wilson, *Scholars of Byzantium*, 137.

156 Wilson, *Scholars of Byzantium*, 26, 112.

in one of his letters.¹⁵⁷ Thus, among the most elite of learned society, of which Leon the Mathematician and Constantine VII's circle surely must count, *Agamemnon* was not unknown, and thus they had a classical, textual antecedent of a long-distance beacon chain.

The total distance of the chain envisioned by Aischylos is about 410 km, and thus shorter than any of the Byzantine routes, but it follows a similar general pattern with long distances at the beginning before a denser sequence of beacon stations in the approach to the final destination. More interesting is that both have a total of nine stations, including the non-transmitting station of Pharos/Argos. While it may be coincidence, the classical precedent may have influenced how many beacons belong on such a list.¹⁵⁸

Conclusions

This study's experiment did not resolve all the mysteries of the optical telegraph, but it did clarify a number of matters. The first is that *in theory* the number of beacons described could complete the circuit from Loulon to Constantinople. In practice, this is impossible to know and cannot be tested: particulate matter and CO₂ in the atmosphere affecting long-range visibility, the need to create platforms to account for the offsets above ground level, and twenty-first-century light pollution are insurmountable obstacles. The enormous distances that need to be covered increase the chances that something might go wrong as well as the complexity and expense of the system. Moreover, even when the system worked, the information that could be sent was minimal and required further confirmation. That the system can only have functioned at night is clear. While these problems may explain the briefness of the existence of the system and highlight issues with optical telegraphs more generally, they are not entirely satisfactory.

A century after the beacons were shut down, Constantine VII alluded to the system in terms of

intellectual competition with Baghdad. No direct link can be demonstrated, but that the functioning of the beacon chain employs knowledge of the longitudinal circumference of the Earth around the same time that intellectuals in the Abbasid court were engaging with Greek astronomical texts and attempting to improve upon Ptolemy's calculations is a coincidence that cannot be ignored. Who actually could have known about the details of this is unclear, but highly detailed information on Byzantine military dispositions was available in the ninth-century Abbasid Caliphate.¹⁵⁹

The reports of Michael III shutting the system down raise the matter of audience. The people in Constantinople could also see the beacons, and they received only one message from it, while military leaders in Anatolia do not necessarily appear to have been recipients, at least not from the beacon chain as described. The practical purpose of the telegraph was to serve as a trip wire and let authorities in Constantinople know precisely when the Abbasid campaigning season began. Even a few days in the context of aggressive Abbasid attacks in the 830s could make a difference. In this sense, the beacon line worked even if it failed to deliver the correct message, since it granted authorities in Constantinople some sense as to whether to expect an Abbasid campaign that year. The system was too inflexible to deal with the annual raiding; that was a matter for local commanders. Leon accomplished a technical wonder designed to outshine the efforts of the best scholars of the Abbasid court by accessing ancient knowledge that Abbasid scholars either could not find or understand. Whether visiting dignitaries were treated to an explanation of how it worked is unknown, but in any case, only a rarefied few would have understood the full implications. That the logistics and practicalities imposed major limitations on the intended functioning of the telegraph only matters a little in the sense that it brought the Byzantine court directly into competition with the best Abbasid intellectuals and rapidly summoned the emperor into the field to do battle with his rival.

However, after al-Ma'mūn's death in 833 and the Amorion campaign in 838, the beacon system became burdensome security theater; the emperor being seen

157 Theodore of Stoudios, *Epistulae* 498.43 (G. Fatouros, ed., *Theodori Studitae Epistulae*, vol. 2, CFHB 31 [Berlin, 1992], 736).

158 Either Aischylos or the Byzantine lists of beacons may have been sufficiently influential to have an impression on no less a literary figure than J. R. R. Tolkien, who names seven beacons in Gondor. When added to an unnamed first beacon, presumably at or around Minas Tirith, and the sighting of the fire from across the Rohan border, the total is also nine stations: J. R. R. Tolkien, *The Lord of the Rings: The Return of the King* (London, 1966), 748.

159 J. Haldon, "Kudāma ibn Dja'far and the Garrison of Constantinople," *Byzantion* 48.1 (1978): 78–90; W. Treadgold, "Remarks on the Work of al-Jarmī on Byzantium," *BSI* 44.2 (1983): 205–12.

doing something by the people of Constantinople in response to a threat from the East came to matter more than the emperor actually taking action.¹⁶⁰ The idea of imperial observational powers extended to the Carolingian realm, where Notker imagined Charlemagne seeing all the comings and goings in Aachen from the windows of his palace.¹⁶¹ The beacon system's visibility left a lasting impression: Byzantine Jews reimagined the telegraph that ran between Israel

and Babylon to signal the new moon in the form of the Anatolian line, and the emperor Leon VI was imagined in the seventeenth century to have possessed a magic mirror that let him view the frontiers instantly.¹⁶² Military information could be sent from the Tauros frontier to the center at near the speed of light, but a great deal of further meaning can be encoded, intentionally or not, ultimately meaning that a signal says a lot more than "enemy sighted."

160 K. Durak, "Performance and Ideology in the Exchange of Prisoners between the Byzantines and the Islamic Near Easterners in the Early Middle Ages," in *Medieval and Early Modern Performance in the Eastern Mediterranean*, ed. A. Öztürkmen and E. B. Vitz (Turnhout, 2014), 167–80, at 167–77; N. Koutrakou, "Psellus, Romanus III and an Arab Victory 'Beyond Any Reasonable Expectation': Some Remarks on Psellus's Perception of Foreign Relations," *Graeco-Arabica* 11 (2011): 319–45, at 319–21.

161 Notker, *Life of Charlemagne* 30 (H. F. Haefele, ed., *Notkeri Balbuli: Gesta Karoli Magni Imperatoris*, MGH ScriptRerGerm, n.s. 12 [Berlin, 1959], 41).

162 J. Niehoff-Panagiotidis and E. Hollender, "Exome שָׁמַח בְּשִׁמּוֹן: The Announcement of the New Moon in Romaniote Synagogues," *BZ* 103.1 (2010): 99–127, at 124–25; C. Mango, "The Legend of Leo the Wise," *ZRVI* 6 (1960): 59–93, at 83–84.

Department of Classics
University of Winnipeg
515 Portage Ave.
Winnipeg, MB, R3B 2E9
Canada

Appendix

Summary Table of Distance

From	To	Distance (km)	From	To	Distance (km)
Loulon	Hasan Dağı	76	Hill 2606m	Samos 5	105
Loulon	Erciyes Dağı	121	Hill 2606m	St. Mamas	233
Loulon	Keçikalesi	75	Aigilos 2	St. Mamas	178
Hasan Dağı	Samos 1	153	Aigilos 3	Samos 1	110
Hasan Dağı	Samos 2	159	Aigilos 3	Samos 2	106
Hasan Dağı	Samos 3	161	Aigilos 3	Samos 3	105
Hasan Dağı	Samos 4	175	Aigilos 3	Samos 4	88
Keçikalesi	Samos 1	154	Aigilos 3	St. Mamas	220
Keçikalesi	Samos 2	161	St. Mamas	Kurban Dağı	35
Keçikalesi	Samos 3	163	St. Mamas	Katırlı Dağı	47
Keçikalesi	Samos 4	175	St. Mamas	Mokilos	71
Keçikalesi	Samos 5	168	St. Mamas	St. Auxentios	101
Samos 5	Mt. Dindymon	139	St. Mamas	Pharos	107
Mt. Dindymon	St. Mamas	228	Kurban Dağı	Mokilos	43
Hill 1812m	St. Mamas	168	Kurban Dağı	St. Auxentios	66
Hill 2606m	Samos 1	169	Kurban Dağı	Pharos	74
Hill 2606m	Samos 2	170	Mokilos	St. Auxentios	61
Hill 2606m	Samos 3	172	Mokilos	Pharos	75
Hill 2606m	Samos 4	174	St. Auxentios	Pharos	16

Summary Table of Locations

Location	Coordinates (DD)	Elevation (meters above sea level)
Aigilos/Mt. Dindymon	39.3028344°N, 31.7504277°E	1809
Aigilos 2	39.9030960°N, 31.3532976°E	1644
Aigilos 3	39.3847906°N, 31.6903329°E	1640
Akhisar	38.29805°N, 34.13308°E	1315
St. Auxentios	40.9704060°N, 29.1639170°E	429
Erciyes Dağı 1	38.51696°N, 35.41125°E	2840
Erciyes Dağı 2	38.52709°N, 35.424°E	3239
Hasan Dağı	38.1267°N, 34.16485°E	3252
Hill 1812m	40.0066602°N, 31.2519210°E	1812
Hill 2606m	38.5047470°N, 31.0980117°E	2606
Keçikalesi	38.06202°N, 34.09745°E	1680
Kyrizos (Katırlı Dağı)	40.3508452°N, 29.6918421°E	695
Kyrizos (Kurban Dağı)	40.3816965°N, 29.2968581°E	1273
Loulon	37.58299°N, 34.69838°E	2072
St. Mamas	40.0639049°N, 29.2839046°E	2410
Mokilos	40.6157127°N, 29.7087161°E	1130
Pharos	41.0024859°N, 28.9768488°E	3
Samos 1	39.0845511°N, 32.9002506°E	1355
Samos 2	39.1483954°N, 32.8772099°E	1455
Samos 3	39.1767006°N, 32.8805015°E	1730
Samos 4	39.1812939°N, 32.6756197°E	1267
Samos 5	38.0930702°N, 32.1820722°E	2055